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# Water Quality Assessment Of Part Of Abakaliki Capital Territory Southeast, Nigeria

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***Abstract:** This work covers the water quality Assessment of Part of Abakaliki, the pH concentration for various sampled locations range between 7.05-7.18 in the dry season and 7.07-7.19 in the rainy season. The TDS Varies between 20 to 590 mg/l in the dry season and 30 to 480mg/l in the raining season. The hardness of water samples varies from 22 to 470 mg/l in the dry season and 25 to 380 in the raining season. The result of the CF and PLI indicate that chromium contamination in the dry season was low in samples LC1, LC5, LC9 and LC11, Moderate contamination was observed in LC4, LC7, LC10 and LC12, while considerable contamination was observed in samples LC2, LC3, LC6 and LC8. Iron contamination was low in LC1, LC4 – LC12 while moderate contamination was observed in LC2 and LC3. Moderate contamination was observed for cadmium in LC6, LC7 and LC8, Considerable contamination was observed for LC1 - LC5, and LC11 - LC12, while LC9 and LC10 were highly contaminated. No contamination was observed for Lead and Arsenic while for mercury, moderate contamination was observed in LC1, LC8, LC9, LC10 and LC12, considerable contamination was observed in LC2, LC3, LC6, LC7, and LC11, while LC4 and LC5 were highly contaminated with mercury.*

***Keywords:** Contamination, water samples, raining season, dry season.*



## I. INTRODUCTION

Water quality is defined as the chemical, physical and biological characteristics of water, usually in respect to its suitability for a designated use. Water is used for, drinking, agriculture and industry depending of the quality of the water. Water is vital for the existence of all living organisms, but is increasingly being threatened by human activities (Maybeck et al. 1989). The impurities present in water reduces its quality when they are above the recommended standard (Njoku et al., 2017a).

The rural communities in Ebonyi state such as the study area depend largely on surface water for their daily water supply. The surface water bodies in form of streams, rivers and ponds are flooded during the rainy season and dry up at the onset of dry season exacerbating water availability as well water scarcity in the area. Women and children waste valuable man hour in search of water for household use. The quality of water provided for domestic use is often questionable increasing wide spray of water borne diseases.

The effort of the government and donor agencies to provide sustainable water supply in the state has not been successful. This has resulted in the dependent of the surface water bodies in ponds for the daily water supply of the inhabitants of the study area. Generally, public water supply is, where it is operational, it is usually characterized by the twin problems of unreliability and poor quantity as a result of inherent lack of electricity to power the water intakes and poor management. general mismanagement of public water supply that leads to the inabilities of utilities to recover various operating costs to handle extensive deterioration of water. With an increasing population in the study area resulting in increase in demand for potable water supply, there is need for alternative water supply for the inhabitants hence the need for this study.

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## II. LOCATION AND GEOLOGY OF THE STUDY AREA

The study area lies between latitude $6^{o}$ 15’N-$6^{o}$23’N and longitude $8^{0}$ 04’E-$8^{0}$ $12^{0}$’E Southeast Nigeria (Fig. 1).

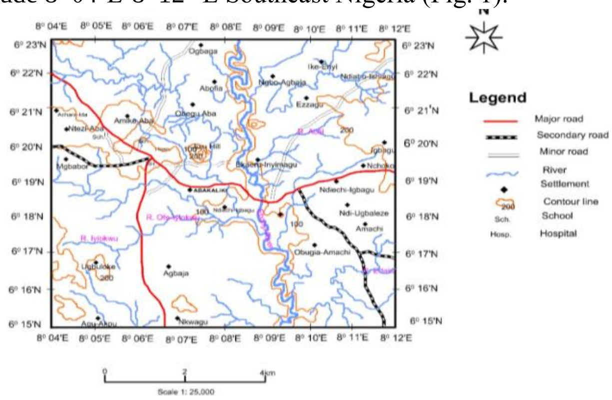


*Figure 1: Location and Accessibility map of the study area*

The study area belongs to the Asu River Group which overlies unconformably the Lower Paleozoic basement and hosts the lead-zinc veins and associated fluorite and barite in the Benue Trough (Reyment 1956). It is an extensive geologic formation in the southern Nigeria Sedimentary Basin with thickness of about 1500m. Simpson (1954) described the Asu River Group as consisting largely of olive brown sandy shales, fine-grained micaceous sandstone and mudstone as shown in Fig.2. The formation is overlain the Eze-Aku Shale of Turonian Age. This is conformably succeeded by the Awgu Shale of Coniacian-Santonian Age, which is in turn overlain by the Owelli Sandstone of Campanian-Maastrichtian Age. (Reyment 1965, whiteman, 1982; kogbe,1989). The extensive Turonian-Coniacian marine transgression deposited the Eze-Aku Shale and the Awgu Shale. Subsidence during the Turonian initiated a new marine transgression, resulting in the deposition of the Eze-Aku Shale with significant sandstone and limestone facies. According to Nwachukwu (1975), the thickness of the two formations – Eze-Aku Shale and Awgu Shale are about 610m and 915m respectively. The Eze-Aku Shale and Awgu Shale are lithologically similar and consist of shales, limestones and sandstones. The formations are overlain by regoliths and ferruginised sandstones in many places.

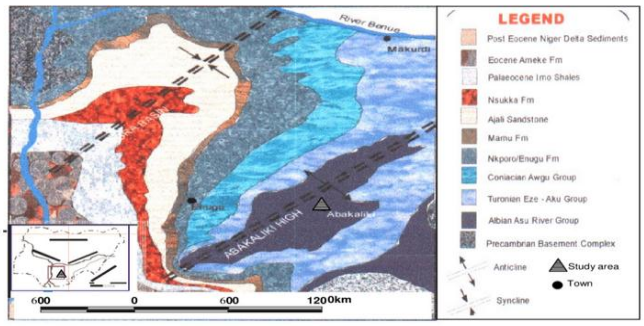


*Figure 2: Generalized Geological map of southeastern showing the distribution of the Asu River group and other lithologic units (Modified After Okogbue and Aghamelu, 2010)*

## III. MATERIALS AND METHODS

Water samples were collected from lakes, streams, rivers, hand dug wells and boreholes. The samples were collected in properly labeled 2 litre plastic cans, filled and tightly corked. Before filling the cans, each was rinsed thrice with the water from source before collection. A total of 12 water samples were collected. The samples include 7 groundwater samples consisting of 2 hand dug wells and 5 borehole samples. Others include 2 water samples from lakes, 1 sample from stream, 1 sample from River, 1 samples collected from saline water pumped from mine-pits. The smples were further transported to a private laboratory in Awka for proper laboratory analysis.

## IV. RESULTS AND DISCUSSION

The water samples were analyzed for various physicochemical parameters in both dry and rainy seasons and the results are presented in Tables 1 and 2 below. The obtained values for the physicochemical parameters were compared with the WHO acceptable limits so as to ascertain if the concentrations were within the recommended limits.

| Parameters | **L1** | **LC2** | **LC3** | **LC4** | **LC5** | **LC6** | **LC7** | **LC8** | **LC9** | **LC10** | **LC11** | **LC12** | **WHO** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ph | 7.18 | 7.13 | 7.11 | 7.08 | 7.08 | 7.08 | 7.12 | 7.10 | 7.10 | 7.05 | 7.06 | 7.09 | 6.5-8.5 |
| TDS mg/l | 40 | 20 | 60 | 40 | 30 | 290 | 20 | 170 | 100 | 590 | 380 | 40 | 500 |
| Conductivity us/cm | 18.6 | 13.8 | 28.6 | 18.5 | 13.4 | 49.1 | 12.6 | 48.8 | 35.7 | 61.6 | 71.3 | 27.4 | 500 |
| Total hardness mg/l | 22 | 134 | 56 | 50 | 44 | 178 | 54 | 64 | 136 | 470 | 90 | 64 | 200 |
| Bicarbonate mg/l | 10 | 7.7 | 25 | 20 | 10 | 195 | 12.25 | 75 | 25.5 | 7.5 | 190 | 12.5 | 250 |
| Chloride mg/l | 17 | 19 | 26 | 23 | 16 | 18 | 25 | 23 | 25 | 55 | 21 | 17 | 200 |
| Sulphate mg/l | 65.3 | 60.22 | 78.83 | 68.38 | 56.48 | 93.89 | 67.48 | 88.57 | 75.88 | 102.2 | 89.4 | 77.2 | 250-500 |
| Zinc ppm | 0.108 | 0.010 | 1.850 | 0.359 | 0.000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | .00 | 0.00 | 5 |
| Chromium ppm | 0.00 | 0.269 | 0.242 | 0.142 | 0.00 | 0.179 | 0.084 | 0.196 | 0.00 | 0.137 | 0.00 | 0.128 | 0.05 |
| Manganese ppm | 0.00 | 0.00 | 0.0902 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.907 | 0.384 | 0.219 | 0.4 |
| Iron ppm | 0.218 | 0.489 | 0.563 | 0.234 | 0.236 | 0.019 | 0.105 | 0.076 | 0.174 | 0.039 | 0.131 | 0.056 | 0.3 |
| Magnesium ppm | 0.873 | 1.157 | 2.814 | 0.875 | 1.546 | 9.042 | 1.159 | 1.661 | 3.059 | 22.897 | 3.505 | 2.088 | 150 |
| Cadmium ppm | 1.246 | 1.794 | 1.728 | 1.457 | 0.934 | 0.668 | 0.465 | 0.390 | 0.278 | 0.192 | 0.167 | 0.123 | 0.05 |
| Calcium ppm | 3.987 | 4.898 | 4.545 | 5.787 | 3.787 | 7.897 | 2.786 | 6.876 | 3.898 | 11.898 | 5.778 | 4.134 | 100 |
| Arsenic ppm | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| Mercury ppm | 0.168 | 0.511 | 0.488 | 0.981 | 0.604 | 0.333 | 0.345 | 0.204 | 0.204 | 0.170 | 0.030 | 0.017 | 0.006 |
| Lead ppm | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |

*Table 1: Concentrations of physicochemical parameters in dry season*

| Parameters | **LC1** | **LC2** | **LC3** | **LC4** | **LC5** | **LC6** | **LC7** | **LC8** | **LC9** | **LC10** | **LC11** | **LC12** | **WHO** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 7.10 | 7.11 | 7.07 | 7.18 | 7.10 | 7.19 | 7.04 | 7.17 | 7.10 | 7.08 | 7.05 | 7.10 | 6.5-8.5 |
| TDS mg/l | 30 | 40 | 50 | 30 | 30 | 270 | 30 | 150 | 120 | 480 | 290 | 50 | 500 |
| Conductivity us/cm | 15.4 | 14.5 | 26.5 | 14.9 | 18.8 | 27.9 | 17.8 | 40.8 | 33.6 | 51.5 | 67.3 | 19.4 | 500 |
| Total hardness mg/l | 25 | 122 | 58 | 49 | 47 | 156 | 59 | 66 | 123 | 380 | 88 | 62 | 200 |
| Bicarbonate mg/ | 9 | 12 | 24 | 22 | 13 | 120 | 13.7 | 70 | 33.3 | 9.6 | 188 | 14.5 | 250 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| l | | | | | | | | | | | | | |
| Chloride mg/l | 15 | 17 | 27 | 22 | 18 | 17 | 23 | 24 | 26 | 54 | 22 | 19 | 200 |
| Sulphate mg/l | 63.3 | 61.22 | 74.83 | 58.38 | 53.48 | 83.89 | 63.48 | 80.07 | 67.08 | 100.04 | 84.05 | 88.01 | 250-500 |
| Zinc ppm | 0.304 | 0.010 | 1.650 | 0.259 | 0.000 | 0.00 | 0.00 | 0.246 | 0.00 | 0.00 | 0.010 | 0.00 | 5 |
| Chromium ppm | 0.00 | 0.256 | 0.142 | 0.132 | 0.00 | 0.177 | 0.074 | 0.156 | 0.00 | 0.122 | 0.00 | 0.125 | 0.05 |
| Manganese ppm | 0.0731 | 0.00 | 0.0648 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0300 | 0.00 | 14.907 | 0.284 | 0.333 | 0.4 |
| Iron ppm | 0.218 | 0.418 | 0.580 | 0.234 | 0.236 | 0.016 | 0.105 | 0.076 | 0.174 | 0.039 | 0.131 | 0.056 | 0.3 |
| Magnesium ppm | 0.773 | 1.447 | 3.814 | 0.875 | 1.546 | 8.042 | 1.559 | 1.781 | 3.059 | 23.897 | 3.605 | 3.088 | 150 |
| Cadmium ppm | 1.246 | 1.694 | 1.828 | 1.357 | 0.834 | 0.768 | 0.665 | 0.390 | 0.278 | 0.192 | 0.167 | 0.133 | 0.05 |
| Calcium ppm | 4.987 | 3.898 | 3.645 | 8.787 | 4.125 | 6.976 | 4.6667 | 5.773 | 4.789 | 9.098 | 4.558 | 2.134 | 100 |
| Arsenic ppm | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| Mercury ppm | 0.147 | 0.668 | 0.344 | 0.871 | 0.554 | 0.533 | 0.445 | 0.134 | 0.344 | 0.154 | 0.060 | 0.015 | 0.006 |
| Lead ppm | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |

*Table 2: Concentration of various physicochemical parameters in rainy season*

The results in tables 1 and table 2 shows that in both seasons, the concentrations of chemical parameters were within the WHO acceptable limits. However, the concentrations of heavy metals such as chromium, cadmium and mercury were observed to be above the permissible limits in both seasons while lead and arsenic were not detected in the analysed water samples.

The pH concentration for the various sampled locations range between 7.05 – 7.18 in the dry season and 7.07 – 7.19 in the rainy season. This indicates that all the analyzed water samples have concentration that are within the safe limit of 6.5 to 8.5 set by WHO. Thus, the measured pH values of the water samples were within permissible values and will not cause any harmful effect to the consumers.

In the present study, TDS varied between 20 to 590 mg/l in the dry season and 30 to 480mg/l in the rainy season. The highest TDS value of 590mg/l in the dry season was observed in sample LC10. This may be due to improper waste management practice and the intense agricultural activities that was observed in the area. Electrical Conductivity EC in this study ranges from 12.6 to 71.3 µS/cm in the dry season and 14.5 to 67.3 µS/cm in the rainy season. The obtained EC values were all within WHO permissible limits. The Total hardness of the water samples varied from 22 to 470 mg/l in the dry season and 25 to 380mg/l in the rainy season. The highest value were observed in sample LC10 in both seasons. Durfor *et al.*, (1964) classified water as soft (0 -60), moderate (61 – 120), hard (121 – 180) and very hard (>181) and based on this classification, samples LC1, LC3, LC4, LC5, LC7 are soft water, LC8, LC11 and LC12 are moderate, LC2, LC6 and LC9 are hard while sample LC10 is very hard in both seasons.

The chloride content of studied water samples was within permissible limit of 200 mg/L prescribed by WHO. In present study, the results of chlorides in all sampling sites ranged from 16 to 55 mg/l in the dry season and 15 to 54 mg/l in the rainy season. These recorded values were observed to be within the permissible limits in both seasons. Sulfate is a naturally occurring anion that is found in almost all types of water and the observed concentration in this study varied between 56.48 to 102.2 mg/l in the dry season and 53.48 to 100.04 mg/l in the rainy season. According to WHO (2008) guidelines for drinking water quality, the threshold level for sulphate is 250 mg/l and in the present study, none of the samples has value greater than the recommended level. Calcium concentrations were observed to vary from 2.786 mg/l to 11.898 mg/l in the dry season and 2.134 mg/l to 9.098 mg/l in the rainy season. According to WHO permissible limit of calcium, the concentration for drinking water is 100 mg/l and as such, the observed concentrations for calcium in this study were all within the acceptable limit.

Magnesium is often associated with calcium in all kinds of waters, but its concentration remains generally lower than the calcium. Magnesium is essential for the Chlorophyll growth and acts as a limiting factor for the growth of Phytoplankton (Solanki, 2012). Magnesium concentration in this study varies from 0.873 to 22.897 mg/l in the dry season and 0.773 to 23.897 mg/l in the rainy season and these values are well within the permissible limit in both seasons.

The concentration of the anions in the study area follow the trend $SO_4^{2-}$ > $HCO^-$ > $Cl^-$ while the cations occur in $Ca^{2+}$ > $Mg^{2+}$ trend.

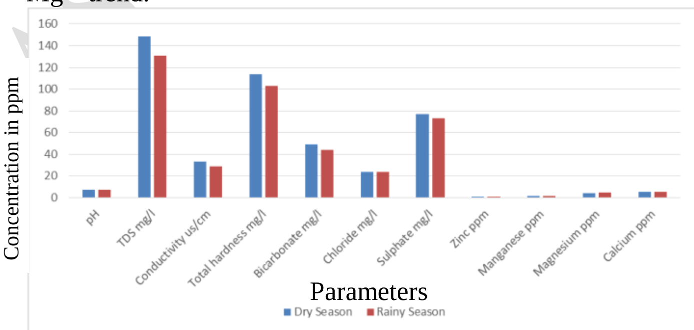


*Figure 3: Bar chart showing the concentration of chemical parameters in dry and rainy seasons*

Trace metals such as zinc, copper, iron and manganese are required by the body in small amounts for metabolic activities. These same elements, at higher concentrations can cause adverse health effects. Zinc toxicity leads to diarrhea, manganese may hamper the intellectual development of a child. Iron has been associated with genetic and metabolic diseases and, repeated blood transfusions and copper toxicity is related to several health concerns, including stomach cramps, nausea, vomiting, diarrhea, cancer, liver damage and kidney disease (Winifred *et. al.*, 2014). However, the concentrations of these elements were observed to be within the permissible limits in both season and as such, they do not pose any health issue.

Toxic metals such as mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), and lead (Pb) have no beneficial effects in humans, as such long-term exposure may cause more severe disruptions in the normal functioning of the human organs where the metals accumulate (Hayelom and Gebregziabher, 2015).

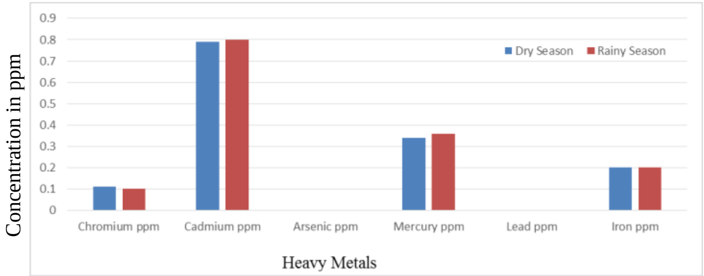


*Figure 4: Bar chart showing the concentration of heavy metals in dry and rainy seasons*

The concentration of heavy metals in both seasons follows the trend Cd > Hg > Fe > Cr > Ar .> Pb.

CONTAMINATION FACTOR (CF) AND POLLUTION LOAD INDEX (PLI)

Contamination factor (CF) is the ratio of the concentration of the element in a sample (Hakanson, 1980) and it was used to determine the contamination status of the water in the present study. Contamination factor is calculated according to Thomilson *et.al.*, (1980) which is given by;

$$CF = [C_{heavy\ metal}]/[C_{background}] \quad (1)$$

The contamination level is classified based on their intensities on a scale ranging from 1 to 6 in table 4.3 below

| Contamination Factor | Intensity |
|---|---|
| <1 | Low Contamination |
| >1<3 | Moderate Contamination |
| >3<6 | Considerable Contamination |
| >6 | High Contamination |

*Table 3: Contamination factor according to Thomilson et.al., (1980)*

On the other hand, Pollution load index (PLI) for the entire samples was determined as the nth root of the product of the n CF.

$$PLI = (CF1 \times CF2 \times CF3 \times \cdots \times CFn)^{1/n} \quad (2)$$

Where CF - CFn = contamination factors

If PLI < 1 indicates no pollution. PLI > 1 indicates polluted water. This empirical index provides a simple, comparative means for assessing the level of heavy metal pollution (Usero et al., 2000).

| Parameters | LC1 | LC2 | LC3 | LC4 | LC5 | LC6 | LC7 | LC8 | LC9 | LC10 | LC11 | LC12 | PLI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chromium ppm | 0 | 5.38 | 4.84 | 2.84 | 0 | 3.58 | 1.68 | 3.92 | 0 | 2.74 | 0 | 2.56 | 0 |
| Iron ppm | 0.73 | 1.63 | 1.88 | 0.78 | 0.79 | 0.06 | 0.35 | 0.25 | 0.58 | 0.13 | 0.44 | 0.19 | 0.44 |
| Cadmium ppm | 4.15 | 5.98 | 5.76 | 4.85 | 3.11 | 2.23 | 1.55 | 1.30 | 9.27 | 6.40 | 5.57 | 4.10 | 1.82 |
| Arsenic ppm | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mercury ppm | 1.68 | 5.11 | 4.88 | 9.81 | 6.04 | 3.33 | 3.45 | 2.04 | 2.04 | 1.70 | 3.0 | 1.70 | 2.16 |
| Lead ppm | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table.4: Contamination factor and pollution load index of heavy metals in the dry season*

| Parameters | LC1 | LC2 | LC3 | LC4 | LC5 | LC6 | LC7 | LC8 | LC9 | LC10 | LC11 | LC12 | PLI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chromium ppm | 0 | 5.12 | 2.84 | 2.64 | 0 | 3.54 | 1.48 | 3.12 | 0 | 2.44 | 0 | 2.50 | 0 |
| Iron ppm | 0.73 | 1.63 | 1.88 | 0.78 | 0.79 | 0.06 | 0.35 | 0.25 | 0.58 | 0.13 | 0.44 | 0.19 | 0.44 |
| Cadmium ppm | 4.15 | 5.65 | 6.09 | 4.52 | 2.78 | 2.56 | 2.21 | 1.30 | 9.27 | 6.40 | 5.57 | 4.10 | 1.87 |
| Arsenic ppm | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mercury ppm | 1.47 | 6.68 | 3.44 | 8.71 | 5.54 | 5.53 | 4.45 | 1.34 | 3.44 | 1.54 | 6.00 | 1.50 | 2.32 |
| Lead ppm | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 5: Contamination factor and pollution load index of heavy metals in the rainy season*

Tables 4 and 5 above shows the contamination factors and pollution load index of the analyzed heavy metals in both dry and rainy seasons and from the results, chromium contamination in the dry season was low in samples LC1, LC5, LC9 and LC11, Moderate contamination was observed in LC4, LC7, LC10 and LC12, while considerable contamination was observed in samples LC2, LC3, LC6 and LC8. Iron contamination was low in LC1, LC4 – LC12 while moderate contamination was observed in LC2 and LC3. Moderate contamination was observed for cadmium in LC6, LC7 and LC8, Considerable contamination was observed for LC1 - LC5, and LC11 - LC12, while LC9 and LC10 were highly contaminated. No contamination was observed for Lead and Arsenic while for mercury, moderate contamination was observed in LC1, LC8, LC9, LC10 and LC12, considerable contamination was observed in LC2, LC3, LC6, LC7, and LC11, while LC4 and LC5 were highly contaminated with mercury.

In the rainy season, chromium contamination was observed to be low in LC1, LC5, LC9 and LC11, moderate contamination in LC3, LC4, LC7, LC10 and LC12, and considerable contamination in LC2, LC6 and LC8. Iron contamination was low in LC1, LC4 – LC12, while LC2 and LC3 were moderate. Cadmium contamination was moderate in LC5 – LC8, considerable contamination was observed in LC1, LC2, LC4, LC11 and LC12, while LC3, LC9 and LC10 has high cadmium contamination. Mercury contamination was high in LC2, LC4 and LC11, considerable contamination was observed in LC3, LC5, LC6 and LC7, while LC1, LC8, LC10 and LC12 were moderately contaminated with mercury. No contamination was observed in the samples for lead and arsenic.



## V. CONCLUSION

The study was carried out in Ebia Area and its environs to ascertain the hydrochemical properties of the water resources in the area. The water was analysis using Atomic Absorption spectrometer techniques for both dry and rainy season, from the result of the analysis the data for various physicochemical parameters and tthe concentrations of chemical parameters were within the WHO acceptable limits. However, the concentrations of heavy metals such as chromium, cadmium and mercury were observed to be above the permissible limits in both seasons while lead and arsenic were not detected in the analysed water samples.

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