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# ASSESSMENT OF WATER QUALITY FROM GROUNDWATER IN AMAWBIA, AWKA SOUTH L.G.A., ANAMBRA STATE

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**Abstract**

The focus of this study is on the assessment of the water quality of groundwater of Amawbia town, Awka South LGA, Anambra State. Experimentation and survey research design were employed in the study. The research covered both physicochemical and microbial assessment of groundwater in the study area. Data obtained were analyzed with SPSS (version 20.0) and Microsoft excel (version 2020). Hypothesis was tested using ANOVA and Pearson Product Moment Correlation Analysis to determine the interactions of the physicochemical variables measured. Field investigation found out that groundwater was the main source of water to the people. The result shows that both wide and slim ranges were observed in the physicochemical parameters analyzed. Among the parameters that exceeded the NESREA and FME limits are pH, BOD, Copper, Chromium and Lead. This therefore creates a big worry, poses a great risk and severe concern with potable water consumption and use by inhabitants in the study area. The Microbial result indicates that THC and TCG values exceeded the FME and NESREA permissible limits. These higher values indicates feacal contamination and would pose a public health risk in the study area. THC and TCG correlated positively with almost all parameters except for pH, zinc, copper, chromium and lead. Amongst other recommendations, there is need for aggressive public awareness to sensitize the inhabitants on the dangers of consuming unwholesome water.

**Keywords:** Assessment, Water quality, Groundwater, Amawbia

## Introduction

Water is a renewable resource that is always in flux, with the balance determined by mass conservation, and all land regions in a river basin are connected by water (FAO, 2012). In recent years, water, the source of life and human civilization, has become one of the most pressing challenges. It is undoubtedly the most precious natural resource available to man, and without a doubt the most important factor for human survival. Water is not only necessary for every cell and organ in the body, but it also makes up two-thirds of the human body's weight and plays a critical part in organisms' existence and survival (Adeniran, 2018).

Despite the fact that water covers 78% of the earth's surface, the amount of water accessible for human use is restricted (Rout and Sharma, 2011).Rapid economic expansion, population increase, and rising living standards have all resulted in ever-increasing demands for fresh water (Moussa et. al., 2020; Shi et. al., 2018, Nkemdirim, 2010).

Water pollution is a serious global problem that affects the health and survival of millions of people in both developed and developing nations (Michele, Richard, and Byron, 2003). Despite the fact that Nigeria is recognized for having plentiful water resources, it cannot be stated to be devoid of water supply and pollution issues. Due to population expansion and the needs of irrigated agriculture, worldwide water usage has increased at more than double the rate of population growth in the previous century, and while there is no global water shortage per se, an increasing number of places are chronically short of water (UN, 2007; Moe and Rheingans, 2006). Millions of people are predicted to die each year due to a shortage of clean, safe drinking water.

Nigeria's rate of urbanization is characterized by high population density, increased industrial and agricultural activities, and indiscriminate disposal of all types of wastes, all of which are perceived to pose serious pollution threats with all of the associated health hazards on groundwater quality, particularly in urban areas. (He, et al, 2018; Alinejad et. al, 2016). Pollution of surface water can create health risks because such waterways are often used directly as drinking water sources or connected with shallow well used for drinking water. Natural factors such as climate, soil type, geology, topography, precipitation, evaporation, and water-rock interactions, as well as anthropogenic factors such as waste disposal, fertilizer application, pesticide spraying, irrigation, and so on, all have an impact on groundwater quality (Coomar e.t al., 2019).

The current research area, Amawbia, is a town in Anambra State, located in the Awka South Local Government Area. The town's distinctive feature has attracted a variety of human activities, services, and associated businesses, all of which have the potential to have both positive and negative effects on the environment. As a result, there is a substantial risk of water quality degradation, especially given the fast increase in human density and commercialization. Achieving long-term groundwater development necessitates a better knowledge of groundwater quality and the factors that cause pollution. As the most prevalent source of fresh water in the study region, the level of qualitative deterioration of groundwater sources is investigated in this study.

**Justification for the study**

According to the World Health Organization/United Nations International Children's Emergency Fund (WHO/UNICEF, 2017 & 2019), billions of people around the world continue to suffer from poor access to safely managed drinking water services, sanitation, and hygiene, with one in every three people in the world lacking safe drinking water. It has also been stated that roughly 2 million individuals are affected by deadly waterborne infections each year, with some cases resulting in high fatality (Naik, 2016).

Water quality testing is not done as frequently as it should be in Africa, and a lack of understanding among those who use the water source causes them to assume that as long as they are drinking from a well, it is safe. Once a supply of water has been established, the quantity of water is frequently prioritized over the quality of the water (WHO, 2015).

Amawbia is a town in Anambra State known for its human settlements, administrative settings, and associated human incursions into the natural environment. Auxiliary industrial operations are closely linked to these human clusters, and they may contribute to the pollution burden of the nearby environment. Given the high danger of groundwater pollution and the varied permeability of the region's soils, there is a need to examine the groundwater quality of the research area as a public health monitoring procedure. This might then be expanded to provide explanations for the area's public health situation and environmental management consequences.

## Geographical Location of the Study Area

Amawbia is a town in Awka South Local Government of Anambra State, Nigeria (see Fig.1 and 2). Its geographical coordinates are 6°12′0.9612″N and 7°02′51.0534″E. The town has six surviving villages: Umueze, Ngene, Adabebe, Umukadibia, Ezimezi and Enu-oji. Amawbia lies within the Anambra Basin whose sedimentary rocks are made up of Nkporo Shale, the Mamu Formation, the Ajali sandstone and the Nsukka Formation as the main deposits. Its soil is basically clayey loamy soil while the vegetation is light forest interspersed with tall grasses.

  

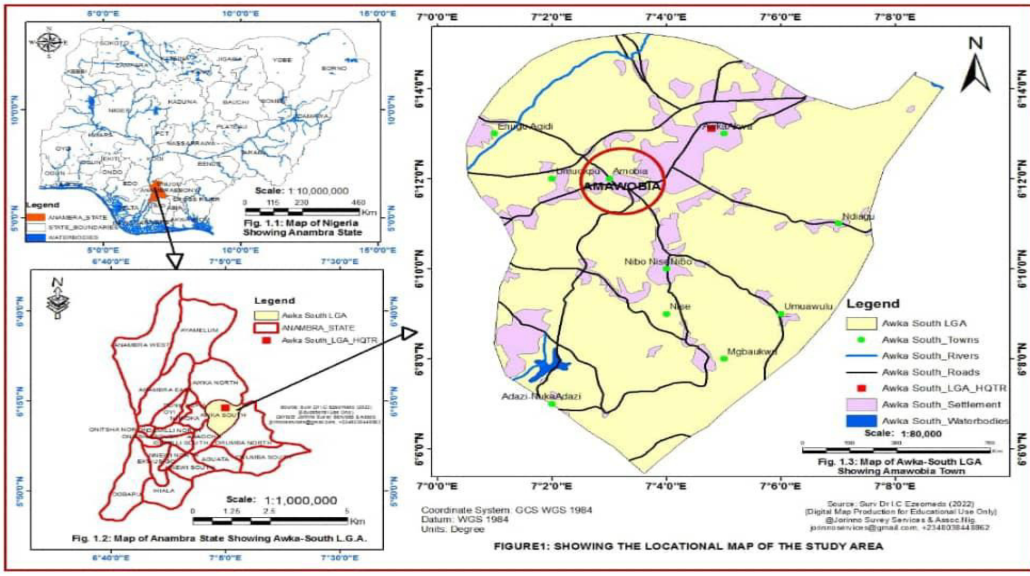


Fig. 1: The Study Area.

Amawbia is located in the transition area between the sub-equatorial and the tropical hinterland climatic belts of Nigeria. The temperatures are generally high, between 25$^o$C and 27$^o$C. The area lies in the rain forest zone of Nigeria with a mean annual rainfall of 1828 mm. The average relative humidity within the study area is generally high throughout the year, with figures between 70-80%.The highest figures are experienced during the wet season and the lowest during the dry (Wikipedia, 2019). The people of Amawbia are mainly involved in agricultural activities and trading.

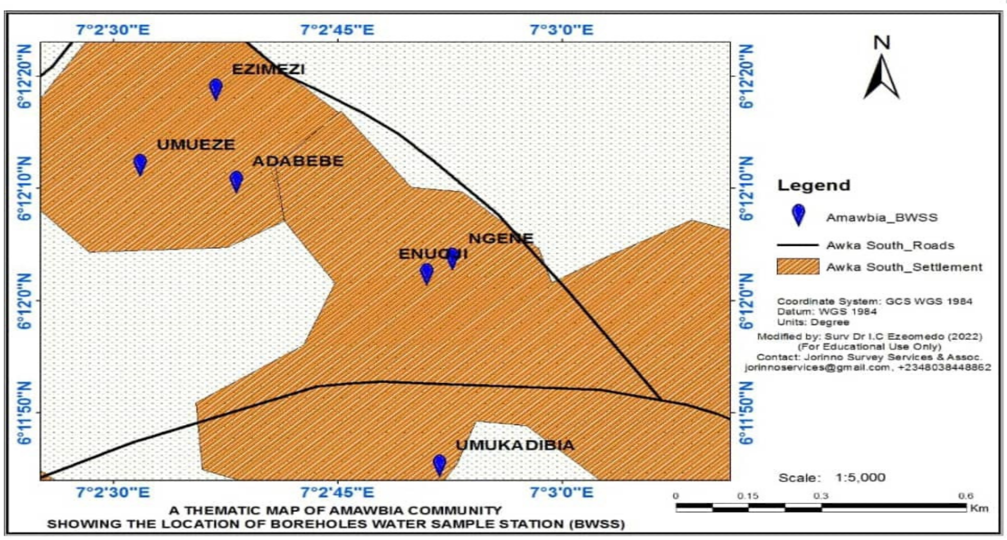


Fig. 2: Amawbia, showing the Six Communities

**Method of study**

The experimentation and survey design were employed in the study. The research was conducted in two phases. These were field observation and sample collection and laboratory analysis. Twelve (12) water samples were systematically taken from boreholes within the community and identified as Sample A, Sample B, Sample C, Sample D… etc… to Sample L. All the 12 boreholes serve as active sources of water supply to inhabitants in the community during the study period. Systematic random sampling method was used to select the area/boreholes. A total of 150 structured questionnaire were administered to respondents. The population includes borehole owners as well as the general public that make use of water from the boreholes for domestic activities.

**Borehole Water Quality Sampling**

At every water sampling location, a 200mL sample bottles were pre-rinsed with the water sample before collection. For microbiological sampling, sterile glass bottles were used. At each sampling point, each bottle is rinsed with the sample before collection. This is to avoid the collection of non-representative sample. In addition, for accurate identification, a descriptive data were written on each sampling container, including the date of collection, collection point, sample number, and location of the site. Water samples were collected from raw water source; all samples were collected in replicates, stored in iced chest and subsequently transferred to the laboratory as soon as possible after collection to maintain their in-situ properties. The samples collected were then subjected to physical, chemical and microbiological analysis in a standard laboratory (Zaharm Analytical and Research Laboratory) in Amawbia, Anambra State with 24 hours.

**Parameters Analysed.**

(a)Physical: Turbidity, Temp

(b)Chemical: pH, BOD, DO, COD, iron, zinc, calcium, magnesium, sodium, total dissolved solids, nitrate, and phosphate. Heavy Metals (Cu, Pb, Cr)

(c)Microbiological: Total Heterotrophic Count (THC) and Total Coliform Group (TCG)

**Methods of analysis (Experimental Design)**

The methodologies employed for analyses were in accordance with APHA (1999). The techniques used in the measurement of the physicochemical parameters (pH, TDS, DO, turbidity, total dissolved solids and metals) of the water samples were studied. The analytical procedures followed the APHA (1999, 2005) standard procedure for analysing water and waste water. The pH was measured with the aid of pH meter, standardized with pH buffer 4.0, 7.0 and 9.0. TDS was estimated by evaporation method at 180°C, D.O, was analysed by standard procedure mentioned in APHA (2005) as reported by Bertram and Balance, (1996), as per standard methods.

**Turbidity**

The turbidity meter (HACH-2100N) was turned on for measurement; the cuvette of the meter was rinsed with de-ionized water. A volume of 10 mL of de-ionized water was dispensed with the cuvette and placed in the meter to calibrate it. A volume of 10 mL of water sample was dispensed in the cuvette and placed in the meter, reading was recorded and the process was conducted in folds.

**Dissolved Oxygen**

This is a test conducted to determine the amount of gaseous oxygen dissolved in water samples. De-ionized water was in a beaker and used to rinse the dissolved oxygen electrode probe. The dissolved oxygen [DO] meter was switched on. The dissolve oxygen meter was standardized and calibrated by dipping the probe into de-ionized water. Then the probe is dipped into the water samples and the reading was taken and recorded. The unit is mg/L.

**Total Dissolved Solids**

The filter paper was placed back in the funnel and moistened with distilled water; 50 ml of well mixed sample water was measured and passed through the filtration system, under suction, thus ensuring all solid in the water were trapped in the paper. The filtrate was evaporated to dryness in a dish (already washed, dried and weighed at constant weight), on a stream bath, and dried further in an oven for 1 hour at 105°C, and cooled in the desiccators and weighed. The process was repeated until constant weight was achieved before recording the results. The process was repeated until a constant was achieved.

**Trace Metals Analysis**

Spectrophotometer [model 1245] was used to determine the concentration of the trace metals such as calcium (Ca), Sodium (Na), Magnesium (Mg), Iron (Fe), Zinc (Zn), Lead (Pb), Copper (Cu) and Chromium (Cr). These are the metals in most borehole waters. A volume of 100 ml well water sample was measured into 150 ml beakers and placed on a plate in the fume compound. A volume of 3 ml of concentrated $HNO3$ was added when the sample volume reduce to 75 ml. A volume of 1 ml of concentrated HCl was added too when it reduces to 500 mL on reduction to 25 ml, the sample was removed and allowed to cool. The sample was then made up to 100 ml with distilled water, reagent blank was also prepared. The liquid solutions were then taken for analysis using atomic absorption spectroscopy UNICAM 919 AA model and appropriate cathode lamps and resonance wave lengths of the metals.

**Statistical Analysis**

Data obtained were analyzed using SPSS (version 20.0) and Microsoft Excel (2020 version). Descriptive statistics and graphical illustrations were used to elucidate the collected data. For this study and test of hypotheses, ANOVA and correlation was performed. The Pearson correlation (r) was used to determine the interactions of the physicochemical variables measured.

**Results and Discussions**

**Physicochemical and Microbial Characteristics of Groundwater Sources in Amawbia**

Table 1 presents a descriptive statistics of the result with NESREA/FME permissible limits.

**Table 1: Descriptive Statistics of the Physicochemical and Microbial Parameters of Groundwater Sources of Amawbia Community**

| Parameters | Minimum | Maximum | Range | Mean | FME/NESREA Guidelines |
|---|---|---|---|---|---|
| Temp | 28 | 36 | 8 | 31.5 | ------ |
| pH | 5.5 | 12 | 6.5 | 7.5 | 6.5-8.5 |
| Turbidity | 100 | 320 | 220 | 182.5 | 1000 |
| DO | 3.21 | 5.42 | 2.21 | 4.13 | ---- |
| Total Dissolved solids | 0.7 | 6.10 | 5.4 | 2.63 | 500 |
| C.O.D | 1.08 | 53.4 | 52.32 | 25.3 | ------ |
| B.O.D | 0.16 | 49.1 | 48.94 | 13.9 | 0.00 |
| Nitrate | 0.15 | 2.2 | 2.05 | 0.97 | 10 |
| Iron | 0.02 | 0.92 | 0.9 | 0.56 | 0.5 |
| Zinc | 0.01 | 0.70 | 0.69 | 0.23 | 5.00 |
| Copper | 0.02 | 1.72 | 1.70 | 1.02 | 0.10 |
| Magnesium | 0.07 | 2.90 | 2.83 | 0.87 | 50 |
| Calcium | 0.32 | 12.46 | 12.14 | 4.33 | ------ |
| Sodium | 0.08 | 6.29 | 6.21 | 1.99 | 200 |
| Chromium | 0.000 | 0.14 | 0.14 | 0.043 | 0.05 |
| Lead | 0.000 | 1.44 | 1.44 | 0.213 | 0.05 |
| THC | 0.000 | 45 | 45 | 17.17 | 0.00 |
| TCG | 0.000 | 12 | 12 | 3.083 | 0.00 |

From Table 1, both wide and slim ranges were observed in the physicochemical parameters of the analysed borehole samples in Amawbia. Among the parameters with wide ranges include parameters of turbidity, COD, BOD, THC, and TCG, while the parameters of pH, Temperature, DO, TDS, Nitrate, Iron, Zinc, and Chromium had slime ranges from the analysed results.

  

Temeprature values ranged between 28°C and 36°C with mean value of 31.5°C (see Fig. 1). The spatial variations from the figure indicates a uniform variation. pH values on the other hand ranged between 5.5 and 12 with a mean pH of 7.5. Fig 1 indicates a sharp variation with a range of 6.5. From Fig. 1, some pH values were observed to have exceeded the permissible limit of 6.5- 8.5 by NESREA and FME.

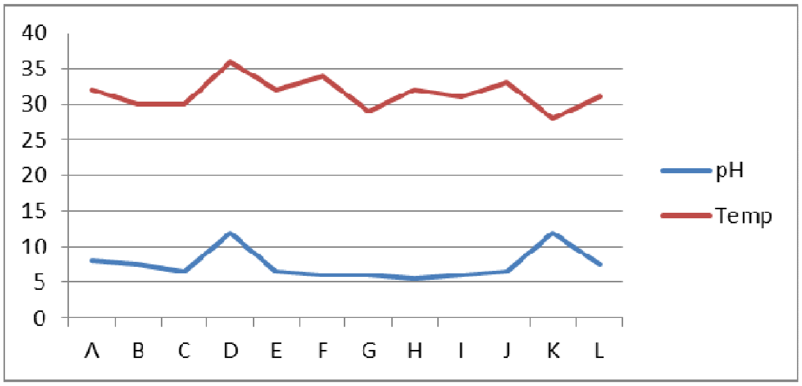


**Fig: 1**: Spatial Variations of pH and Temperature for the water samples

Turbidity ranged between 100mg/l and 320mg/l with a sharp range of 220mg/l. See fig. 2 for the variation. The results were within the permissible limits of 1000mg/l of the FME/NESREA.

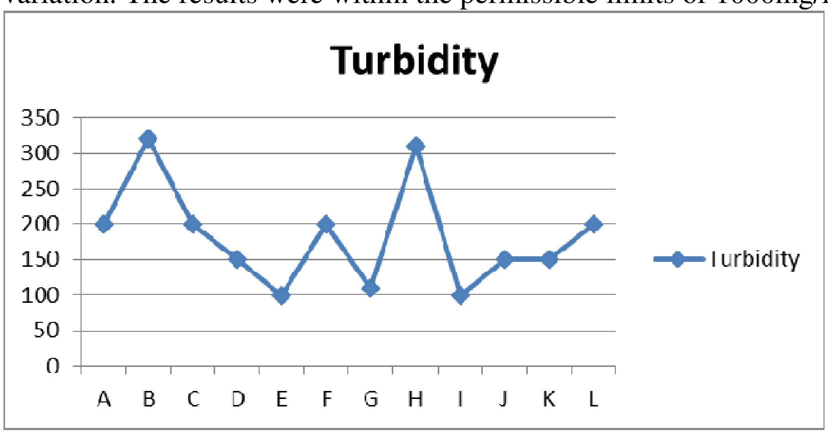


**Fig: 2:** Spatial Variations of turbidity for the water samples

Dissolved oxygen ranged between 3.21mg/l and 5.42mg/l with a mean of 4.13mg/l and a range of 2.21 mg/l.. Total Dissolved Solids (TDS) had a range of 5.4 mg/l with values ranging from 0.7 mg/l and 6.10 mg/l and mean values of 2.63 mg/l. The values were within the permissible limit of FME/NESREA. The variations are depicted in Fig 3. The Chemical Oxygen Demand (COD) values of the borehole samples ranged from 1.08 mg/l and 53.4 mg/l with a sharp variation within the study area (Fig. 4). The observed data were within the permissible limit of FME/NESREA of 500 mg/l.

  

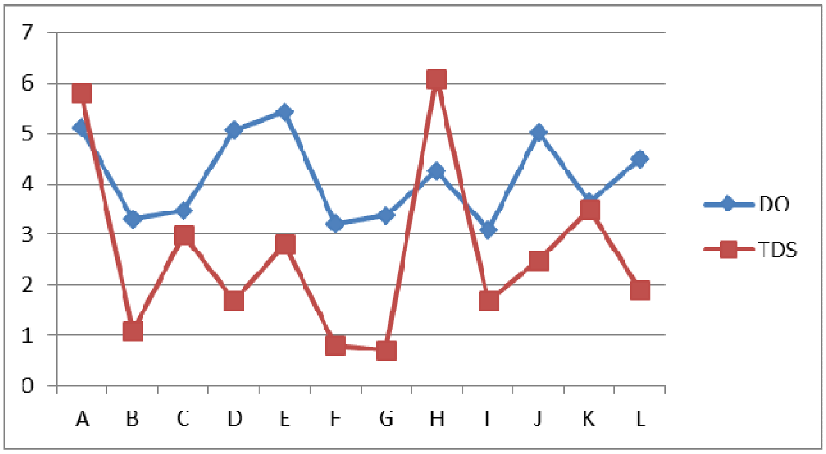


**Fig. 3:** Spatial Variations of DO and TDS for the water samples

Biological Oxygen Demand (BOD) values from the study area ranged between 0.16 mg/l and 49.1 mg/l with a wide variation and range of 48.94 mg/l and a mean of 13.9 mg/l. See Fig. 4 for the graphical distribution and variation of the parameter as observed from the sampled data. The observed data did not conform to the benchmark and standard of 0.000 for the water quality data.

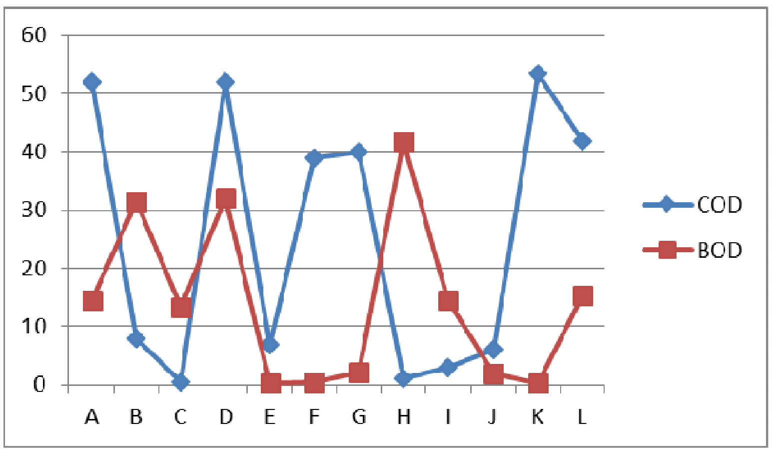


**Fig. 4:** Spatial Variations of COD and BOD for the water samples

Nitrate values from the sampled boreholes ranged between 0.15 mg/l and 2.2 mg/l with a range of 2.05 mg/l and a mean of 0.97 mg/l. The observed values were within the permissible limits of FME and NESREA. Iron values ranged between 0.02 mg/l and 0.92 mg/l with a range value of 0.9 mg/l indicating a narrow range. The observed variations are presented in Fig 5. Thus the observed values did not exceed the FME/NESREA permissible limits.

  

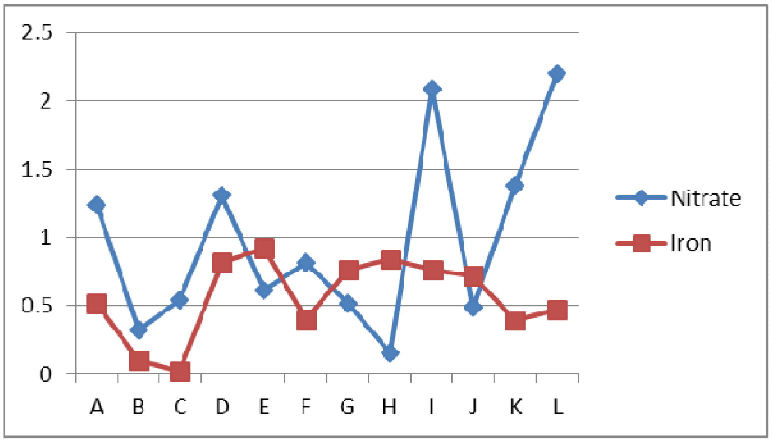


**Fig. 5:** Spatial Variations of Nitrate and Iron for the water samples

Zinc values ranged from 0.01 mg/l and 0.70 mg/l with a mean value of 0.23 mg/l and a range of 0.69 mg/l. As observed, the values were within the permissible limits. Copper values ranged between 0.02 mg/l and 1.72 mg/l with a mean value of 1.02 mg/l and a range of 1.70 mg/l. The observed values exceeded the permissible limit of 0.10 mg/l of FME and NESREA and therefore pose a risk in the study area. It perhaps indicates a sharp and severe concern with potable water consumption and use in the study area. See Fig. 6 for the spatial variation of the parameters.

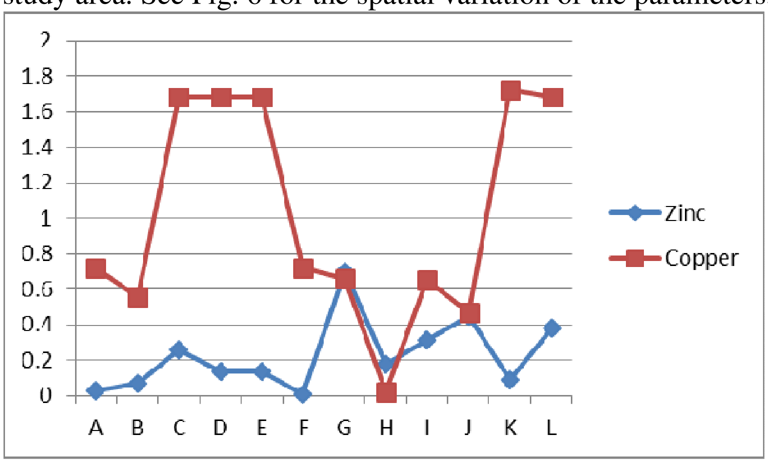


**Fig. 6:** Spatial Variations of Zinc and Copper for the water samples

Magnesium data ranged between 0.07 mg/l and 2.90 mg/l with a mean value of 0.87 mg/l and a range of 2.83 mg/l. The spatial variation indicates conformity with FME/NESREA permissible limits (Fig. 7). Calcium values ranged from 0.32 mg/l to 12.46 mg/l with a mean value of 4.33 mg/l and a range of 12.14 mg/l. Sodium (Na) variation and values ranged from 0.08 mg/l to 6.29 mg/l with a mean value of 1.99 mg/l and a range of 6.21 mg/l. The values were within the permissible limits of FME and NESREA (see fig. 7 for the spatial variations of Mg, Ca, & Na).

  

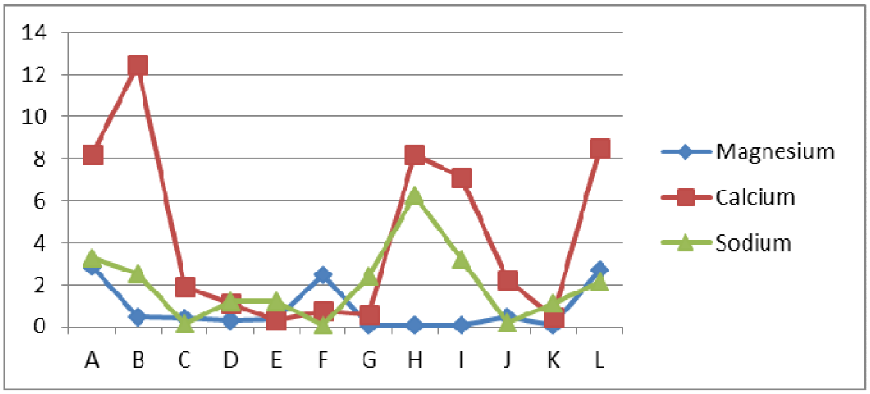


**Fig. 7:** Spatial Variations of Mg, Ca and Na for the water samples

Chromium values ranged from 0.000 (not detected) to 0.14 mg/l and a mean of 0.043 mg/l. The values exceeded the FME / NESREA permissible limits and therefore pose a significant risk to humans who depend on the water for their domestic needs. Lead (pb) values ranged from 0.000 (not detected) and 1.44 mg/l with a range value of 1.44 mg/l and a mean values of 0.213 mg/l. The observed values also exceeded the FME/NESREA limits of 0.05 mg/l. This creates a big worry to the inhabitants more especially those who consume this polluted water with wide health risks. See fig. 8 for their spatial variations.

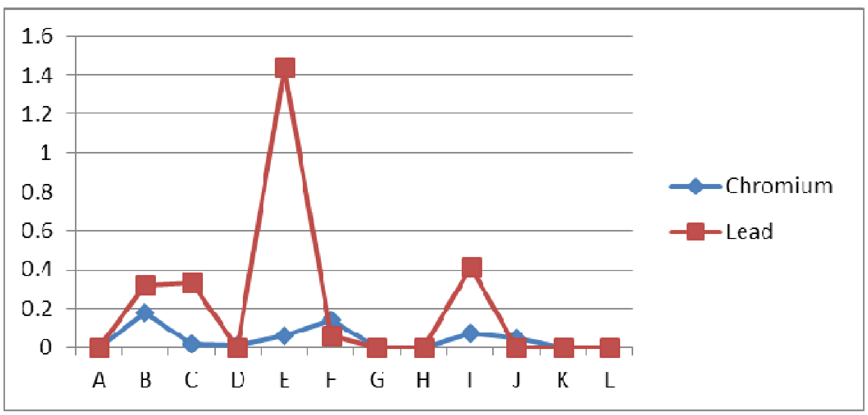


**Fig. 8:** Spatial Variations of Chromium and Lead for the water samples

THC values ranged from 0.000 (not detected) and 45 mg/l and a mean value of 17.17 mg/l. The values (Table 1) exceeded the FME and NESREA permissible limits. As a microbial parameter, these values indicate feacal contamination and would pose a great risk of public health and water borne disease risks in the study area (Fig. 9).

  

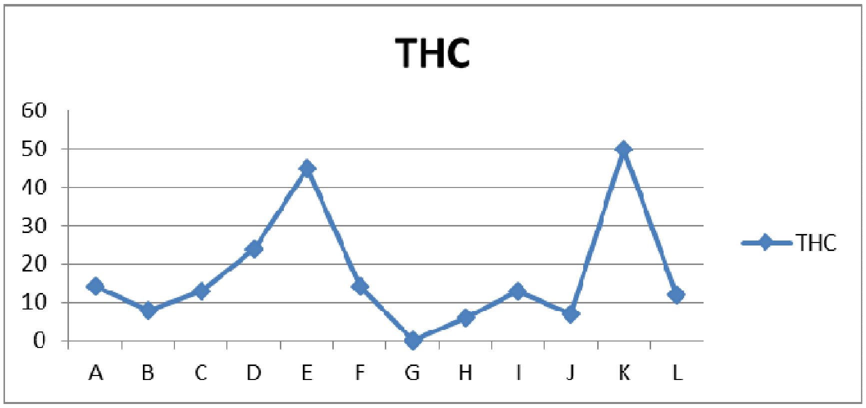


**Fig. 9:** Spatial Variations of THC for the water samples

TCG values ranged between 0.000 (not detected) and 12 mg/l with a mean value of 3.083 mg/l and a range of 12 mg/l. The sharp variation is depicted on Fig. 10.

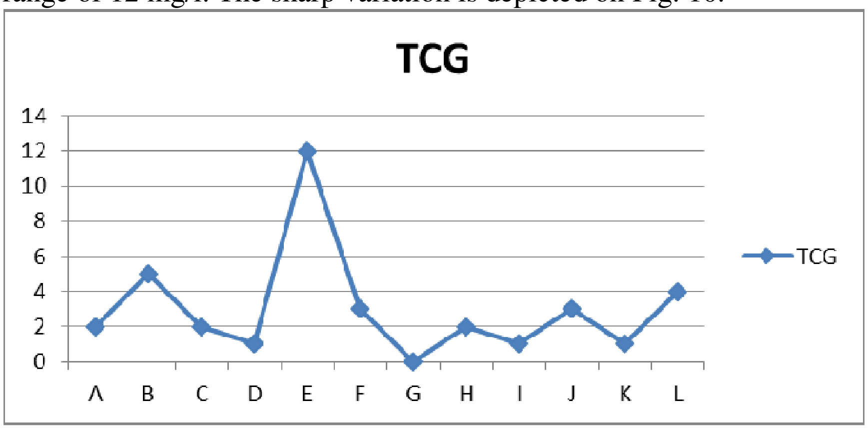


**Fig. 10:** Spatial Variations of TCG for the water samples

The observed values exceeded the FME and NESREA permissible limits and also indicate a foul trend as regards the microbiological parameter and its implications in the study area.

**Statement of** Hypothesis

i. $H_o$ – There is no significant difference in the physicochemical and microbiological qualities of the groundwater in the study area.

ii. $H_o$ – There is no significant correlation with the physiochemical and microbial parameters in the study area.

**Hypothesis Testing**

Hypothesis 1 was tested using the test statistics of Analysis of variance (ANOVA). From the data on (Table 1, apart from FME/NESREA Guidelines) the result of ANOVA is presented on Table 2, summarized with statistical package of SPSS v. 20 and Minitab for windows.

  

**Table 2:** ANOVA table summarized with SPSS statistical package.

| | Sum of squares | Degree of freedom | Mean square | F- ratio |
|---|---|---|---|---|
| Between groups | 311261.069 | 13 | 23943.159 | 3.540 |
| Within groups | 13528.736 | 2 | 6764.368 | |
| Total | 324789.806 | 15 | | |

$F_{cal}$ = 3.540; $F_{tab}$ 0.05 = 19.43; $F_{tab}$ 0.01 = 99.43

Decision rule: Accept $H_o$ if $F_{tab} > F_{calculated}$ otherwise, reject the $H_o$.

Since $F_{0.05}$ (19.43) > $F_{calculated}$ (3.54) and $F_{0.01}$ (99.43) > $F_{calculated}$ (3.54), we accept $H_o$ at 0.01 and 0.05 confidence levels and conclude that there is no significant difference between the physicochemical and microbial parameters of the water samples in Amawbia. It thus implies that the spatial variation of the parameters analysed from the study area was not significantly different within them as the observed results were similar in concentration and had indicates a common source of pollution levels and level of human activities contributing to water contamination in the study area.

**Hypothesis II** was tested using Pearson's Product Moment Correlation Analysis. The correlation coefficient (r) measures the degree of association that exists between two variables (x and y). Microsoft Excel was used to obtain the value of correlation coefficient (r) (see appendix).

From the data (see appendix), at P value <0.05, pH of the samples correlated positively with turbidity (r = 0.565), dissolved oxygen (r = 0.513), Iron (r = 0.845), Zinc (r = 0.845) and at P<0.01, pH also correlated positively with Total dissolved oxygen (r = 0.714), Copper (r = 0.679), Chromium (r = 0.899) and lead (r = 0.811). Other parameters did not show a correlation; - chemical oxygen demand, biological oxygen demand, nitrate, magnesium and calcium at either P <0.05 or P < 0.01.

At P<0.05, turbidity correlated positively with dissolved oxygen (r = 0.613), biological oxygen demand (r = 0.571), iron (r = 0.571), and lead (0.812) while at P<0.01, turbidity correlated with total dissolved solid (r = 0.928), zinc (r = 0.631), copper (r = 0.651), chromium (r = 0.712). At both P<0.05 ad 0.01, there was no significant correlation with chemical oxygen demand, nitrate, magnesium and calcium. It then implies that high turbidity increases the concentration of these parameters accordingly.

At P< 0.01 and P<0.05, dissolved oxygen had significant correlation with total dissolved solids (r = 0.791), chemical oxygen demand (r = 0.500), biological oxygen demand (r = 0.750), zinc (r = 0.564), magnesium (r = 0.521), chromium (r = 0.761), lead (r = 0.651). There was no significant correlation with nitrate, iron and calcium.

At P< 0.01 and P< 0.05, total dissolved solids correlated with chemical oxygen demand (0.921), biological oxygen demand (r = 0.811), nitrate (r = 0.831), iron (r = 0.770), zinc (r = 0.777), copper (r = 0.892), magnesium (r = 0.709), calcium (r = 0.651), and lead (0.944) except for nitrate, magnesium and calcium.

Chemical oxygen demand correlated with biological oxygen demand (r = 0.550), iron (r = 0.711), zinc (r = 0.541), copper (r = 0.908), chromium (r = 0.541) and lead (0.944) except for nitrate, magnesium and calcium. Except for magnesium and calcium, biological oxygen correlated at P< 0.05 and P<0.01, with nitrate (r =0.545), iron (r =0.501), zinc (r = 0.787), copper (r = 0.902), chromium (r = 0.788), lead (r = 0.752). Nitrate correlated positively with iron (r = 0.675), copper (r = 0.822), Magnesium (r = 0.560) calcium (r = 0.581), chromium (r = 0.903), lead (r = 0.793) except for zinc.

  

Also Iron correlated positively with zinc (r = 0.561), copper (r = 0.959), chromium (r = 0.695), and lead (r = 0.557) Zinc correlated with copper at ($P<0.05$) at (r = 0.864), magnesium (r =0.637), calcium (r = 0.710), and lead (r = 0.756) except for chromium. Copper correlated with chromium (r = 0.531), and lead (0.543) at $P< 0.01$ except for magnesium and calcium. THC and THC correlated positively with almost all parameters except for pH, zinc, copper, chromium and lead.

**Table 3:** Correlation (r) matrix of the physicochemical parameters and total coliforms in groundwater sources of Amawbia Community

| | Temp | pH | Turb | DO | TDS | COD | BOD | NO3 | Fe | Zn | Cu | Mg | Ca | Na | Cr | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| THC | 0.534* | 0.431 | 0.643* | 0.542* | 0.546* | 0.657* | 0.546* | 0.654* | 0.540* | 0.346 | 0.432 | 0.640* | 0.547* | 0.600* | 0.320 | 0.011 |
| TCG | 0.573* | 0.341 | 0.750* | 0.500* | 0.344 | 0.544* | 0.674* | 0.653* | 0.521* | 0.435 | 0.272 | 0.582* | 0.602* | 0.461 | 0.500 | 0.371 |

*significant at $P<0.05$

**Decision**:

Since at $P<0.05$, pH correlated positively with turbidity, dissolved oxygen, iron, zinc and at $P<0.01$ with total dissolved solids, copper, chromium and lead. Turbidity also correlated significantly with dissolved oxygen, biological oxygen demand, iron, lead, total dissolved solids, zinc, copper and chromium. Nitrate also correlated positively with iron, copper, magnesium, calcium, chromium, and lead. The microbiological parameters also correlated with some of the physiochemical parameters of the analyzed samples and heavy metals; we reject the null hypothesis that there is no significant interaction between physiochemical and microbial variables in the borehole samples in the study area and accept the alternative hypothesis.

**Interpretation:** This result indicates that the presence of certain indicator will influence the presence of some other parameters of physicochemical and microbial indices. For example, a higher TDS means that there are more ions in the water, the turbidity increases. Thus by measuring the water's turbidity by the number of elements available in the water, we can indirectly determine its TDS concentration. At a high TDS concentration, water becomes loaded with extraneous materials including biological contents. Thus, the positive relationship observed among chemical oxygen demand, BOD, nitrate, iron, magnesium, calcium, THC and TCG, confirms that increasing TDS could encourage microbial proliferations, resulting in more loads in water bodies.

## Conclusion and Recommendation

From the study, it was observed that there were slim and wide variations in the physicochemical and microbial constituents measured in groundwater sources as compared with the FME/ NESREA standards. Thus, some parameters exceeded the desired benchmark for domestic uses. These parameters include pH, iron, copper, chromium, lead and microbial parameters. The laboratory results of the samples analyzed showed that there will be serious environmental concern over time as some of the tested parameters were above the maximum permissible limits by FME/ NESREA. The study therefore recommends that the groundwater sources in the six communities be treated for heavy metal pollution, and feacal microbial contaminants.

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