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Physico-Chemical Analysis of Groundwater in Amukachi and Obiudo Akabo, Ikeduru Local Government Area of Nigeria.

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Abstract:
Water is essential to life and access to safe and clean water is a basic need. Scarcity and pollution of water could have serious health implications. The study of water quality tells us about the present state of useable water for domestic as well as industrial use. This study aimed to determine water quality parameters in borehole water samples from Amukachi and Obiudo Akabo in Imo state, Nigeria. The water samples were collected and analyzed using different types of analytical techniques. The parameter analyzed and the results of their mean value on the physical and chemical parameters include: Color 22PCU, Temperature 26.6^{o}C, Conductivity 9.95µS/cm, pH 5.77, TDS 5.97mg/l TSS 0.38mg/l, calcium hardness 1.47mg/l, magnesium 0.545 mg/l, total hardness 2.0mg/l, chloride 0.02mg/l, alkalinity 0mg/l and the anions analyzed using HANNA HI83200, Multi parameter Bench photometer gives the mean value of the following anions nitrate 0.075mg/l, sulphate 0mg/l and phosphate 0.05mg/l. The results gotten from the analysis of the cations which is the heavy metals using atomic absorption spectroscopy give the mean value of the heavy metal, K 1.56mg/l, Na 0.64mg/l, Pb 0.10mg/l, Cu 0.045mg/l, Fe 1.095mg/l, Cr 0.002mg/l. Cd 0.0035mg/l, Zn 0.005mg/l and Mn 0.615mg/l. The mean values of the parameters were compared with World Health Organization (WHO) standard for drinking water.

Key Words*: Groundwater; Water Quality; Industrial Use; WHO;*

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I. Introduction

Water is essential to life, it is not just a vital natural resource, it is also essential to many sectors of life for instance agriculture, industries, and many other areas. Scarcity and contamination of water could have serious health implications. Access to safe useable water, therefore, remains a global need for all human being [1]. According to UNESCO in the year 2007 eighty percent of the diseases and deaths in developing countries are related to water contamination and deterioration in water quality is responsible for about 3% of death occurrences worldwide [2]. When groundwater is polluted, it poses a great threat to the health of living organisms present in such an environment [3]. In Nigeria, there is an increased reliance on groundwater than on surface water resources for domestic use. It is estimated that almost 60 percent of the people living within urban areas rely on wells for water supply [4]. This trend of over-reliance on groundwater compared to other sources seems to be partially due to the lack of alternative sources and peoples' perception of groundwater as being less contaminated than other sources. The availability of low-priced well drilling technologies also contributes to the penchant for groundwater over other water sources [4]. The problem of safe and potable water supply poses serious threats to humans. Hence, the need to ascertain the quality of all sources of water available to households and industries becomes imperative. The aim of this study is to carry out a quality assessment of the water used for both drinking and agricultural purposes in Amukachi and Obiudo communities of Akabo in Imo state, Nigeria.

Description of Study Area

Location, Accessibility, and Geology.

Akabo is a village complex in Ikeduru Local Government Area of Imo State, Nigeria, West Africa,. Akabo lies on the west of the Okitankwo River, about 10 kilometers northeast of the Imo state capital of Owerri, but a distance of 20 km by road. It is bordered by towns like Mbieri in the north, Iho and Uzoagba in the northeast, Amatta in the east, Orji to the south, and Ubomiri in the west. The major villages of Akabo are Umunnemoche, Amii, Amukachi, Umuiyi, Umuekpere , Umuebem , Obiudo and Amuzu [6]

Figure 1: Image showing Akabo Village in Imo State and surrounding communities (source: Wikipedia)

II. Material And Methods

Experimental Methods

Description of the Study Area Based on the Map

The study area is located in Imo State, South Eastern Nigeria with coordinate:

Latitude - 5^0 33’ 40” N, and 5^0 35’ 0” N

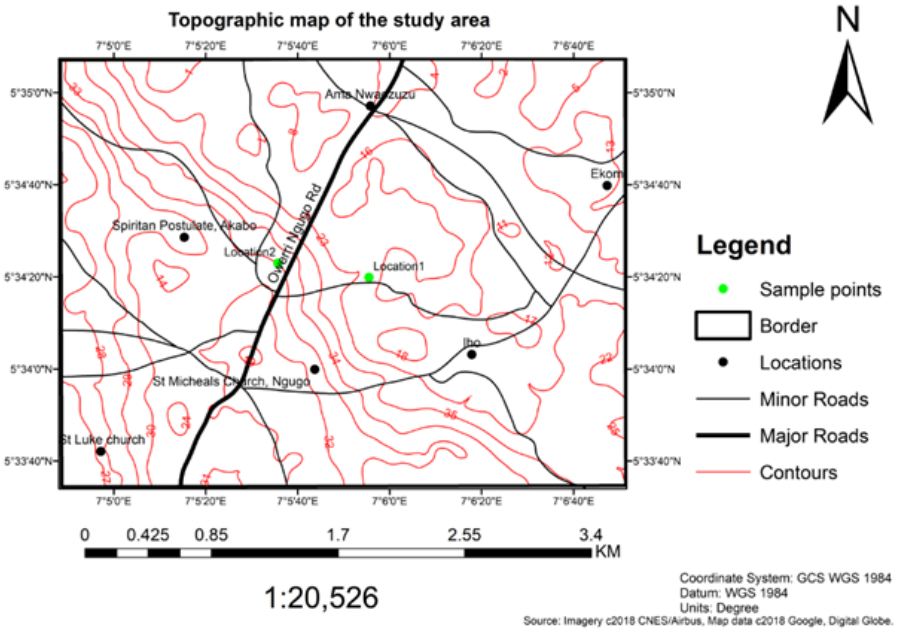
Longitude 7^0 5’ 0” E, and 7^0 6’ 40” E

The scale of the map is 1: 20, 526, the study area is accessible through Owerri – Ngugo road which is the major access route with other minor roads. Neighboring communities include Ama Nwaozuzo, Ekom and Iho.

Samples were collected at locations 1 and 2 as indicated on the map and these locations represent two boreholes in the study area. They are separated by a distance of 617.8 meters apart, location 2 stands at an elevation of 33m, while location 1 stands at an elevation of 23m, as such if borehole 2 is contaminated there is every tendency that borehole 1 will also be contaminated due to the direction of flow and gradient as it is known that higher elevations are recharge areas. Whereas low elevations are discharge areas as indicated from the contour which represents point of equal elevation.

The study areas are sparsely populated with farming as the major activity of the people. The study area is covered with thick vegetation which indicates organic-rich soil. From the laboratory analysis of the study area. It was discovered that the borehole at Amukachi is polluted with Mn of 0.8mg/l and the borehole at Obiudo is polluted with the Mn concentration of 0.4mg/l not up to WHO standards. 0.05mg/l Fe and Pb in drinking water were also observed to be in high concentration.

Fig. 2. Map showing the location of water sample



Sample Collection

The samples were collected with two different white six (6) liters containers which were thoroughly washed and rinsed with the sample before collection. Before each sample collection of the water sample. The tap was purged, that is, all stagnant water from the pipe was flushed out. This was done by allowing the water to flow for a while for ten minutes before the sample was collected. The cans were labeled with paper tape based on their sampling point (location). The water collection was done on the 13th of July 2018 within the duration from 7:00 am to 8:30 am during morning hours.

Determination of Physical Parameters

Color Test

Test for color using 83200 multi-parameter bench photometers.

Specification

Range 0 to 500 PCU (Platinum cobalt unit)

Light source Tungsten lamp with a narrow band interference filter.

Method adaptation of the standard method for the examination of water and wastewater.

Determination of Conductivity.

The conductivity test was carried out using a conductivity meter. The conductivity of both the raw and treated water were carried out. The water was obtained in a beaker where the electrode of the conductivity meter was rinsed with distilled water and placed in the sample. The read button on the meter was pressed which displayed the conductivity of the water sample. Which is expressed in mg/l.

Temperature Determination

The temperature was determined in the sampling point as institute temperature due to its unstable nature. A mercury-filled centigrade thermometer calibrated from 0^{0C} to 100^{0C} was used for temperature measurement.

Determination of pH

The pH of the water sample was determined by using a consort digital pH meter. The pH meter was standardized with a buffer solution of pH 7 and 14 to set the instrument. The pH of the water samples was determined by immersing the glass electrode into the water sample and taking the reading.

Determination of total dissolved solids.

Principle: A known volume of well-mixed sample is evaporated in a pre-weighed dish and dried to constant weight in an oven at 103^0c – 105^0c. The increase in weight over that of the empty dish gives the total solid.

Apparatus: Evaporating dish, drying oven, desiccators, measuring cylinder, weighing balance.

Procedure

A large evaporating dish was washed with clean water and heated in an oven at 105^0c for 1 hour and cooled in a desiccator and weighed. Then 200ml of the well-mixed sample was transferred into the measuring cylinder and transferred into the pre-weighed evaporating dish and evaporated to dryness in a heated drying oven and cooled in a desiccator and weighed. The process of drying, cooling and weighing was repeated until a constant weight

was obtained. The difference in weight gave the weight of the total solids in the sample. Total solid was calculated in milligrams per liter as follows.

$$\text{Total solid in mg/l} = \frac{(W_1 - W_2)\ \text{g}\ (1000\text{mg/g})\ (1000\text{ml/l})}{\text{Sample volume (ml)}}$$

W_1 = Weight of dried residue + dish
W_2 = Weight of empty dish

Determination of total suspended solids (TSS)
The total suspended solids were easily obtained by a simple calculation,
Total suspended solid = Total solid – Total dissolved solid.

Determination of Chemical Parameters
Test for Alkalinity
100mls of the sample water was measured into the conical flask where phenolphthalein indicator was added. The color remains unchanged. A methyl orange indicator was added which changed the color to yellow 0.1m HCl was titrated against the mixture in the conical flask up to the attainment of a reddish coloration which marked the endpoint of the first titration. Where the reading was taken. The mixture in the conical flask was boiled and allowed to cool where the same 0.1m of HCl was again titrated against the mixture that is the second titration up to the formation of a faint yellow colouration. The second reading was taken. The first reading and the second were summed and multiplied by (50) which is the approved standard conversion factor to obtain the total alkalinity of the final water expressed in mg/l.

Test for Hardness
50ml of raw and final water were measured into a separate conical flask 2ml of buffer solution were added to each sample. The colour remained unchanged. A small amount of monochrome black T was added to each sample. A pink coloration was observed.
The samples were titrated with ethylene diamine tetra-acetic acid (EDTA) up to the observance of a blue coloration. The titre value of both raw and final water samples was multiplied with (44.892) as the approved conversion factor where the hardness of both raw and final water was expressed in mg/l.

Table 1 Qualitative representation of water according to hardness

Classification	Concentration $CaCO_3$ (ppm)
Soft water	hard 75 – 150
Hard	150 – 300
<75 Moderate	

Test for Calcium
50ml of both raw and final water were measured into a separate conical flask and 2ml of 0.1M of NaOH was added to the sample, their colour remained unchanged. A small amount of methoxide was added to the samples and violet coloration was obtained. The sample was titrated with ethylene diamine tetra-acetic acid (EDTA) till a permanent pink colour. The titre value of both raw and final water was multiplied by (18.025) as the standard conversion factor. The concentration was expressed in mg/l.

Determination of Magnesium Hardness
In order to determine the magnesium hardness, immediately after the end point of calcium hardness, to the same sample was added 3ml of 5.0M HCl then 6ml of concentrated NH_3 solution was added and a small amount of monochrome black T indicator titrated with EDTA until a faint blue color appeared. Then the color indicator changed from wine red to blue.

Determination of Total Hardness
Using the EDTA Titrametic method
In alkaline condition EDTA (Ethylene – diamine tetra-acetic acid) as its sodium salt reacts with a cation forming soluble chelated complexes when added to a solution. When a small amount of dye such as monochrome black T is added to an aqueous solution containing calcium and magnesium ions at alkaline pH of 10.0 ± 0.1.µ forms a wine-red color. When EDTA is added as a titrant all the calcium and magnesium ions in the solution get complexed resulting in a sharp color change from wine red to light blue, marking the end point of the titration.

Total Chlorine
Light source tungsten lamp with narrow band interface filter at 525nm.
Method adaptation of the EPA DPD
Method 330.5. the reaction between the chlorine and the DPD reagent causes a pink tint in the sample.
Procedure
Select the total chlorine method using the procedure described in the method selection section
-fill the cuvette with 10ml of unreacted sample cup to the marks and replace the cap.
-place the cuvette into the holder and close the lid.
-press timer and the display will show the countdown prior to the measurement or alternatively, wait for 2 minutes and 30 seconds and press read. When the timer ends the meter will perform the reading. The instrument displays the result in mg/l of total chlorine. 3.4Determination of Anions using multi-parameter HI83200 Bench photometer.

Determination of Nitrate
Light source Tungsten lamp with narrow band interference filter @525nm of the cadmium reduction. Adaptation method, the reaction between reagents caused an amber tint in the sample.
Determination of Phosphate
Method adaptation of the standard method for the examination of water and wastewater 18th edition, Amino acid method. The reaction between phosphate and reagents caused a blue tint in the sample.
Determination of Sulphate
Light source Tungsten lamp with narrow band interference filter @ 466nm
Sulfate is precipitated with barium chloride crystals. Light absorbance of the suspension is measured.

Reagent
HI 93751-01 Reagent for 100 test.
HI 93751 – 03 Reagent for 300 test.

Determination of Heavy Metals (Cu, Fe, Cr, Zn, Mn, Cd, Pb, K and Na)
Apparatus: Atomic absorption spectrophotometer (AAS).
Procedure
500ml of unfiltered water sample was transferred into 1000ml beaker to which 2ml of conc. HNO_3 was added and heated to boil on a hot plate until the volume was reduced to about 15 – 20ml. This was cooked and transferred to a volumetric flask (25ml) and made up to the mark.

Standard solutions of suitable strength for individual metals were prepared. The blank, standard solutions and samples were aspirated into the flame atomic absorption spectrophotometer. The calibration curves were plotted and the concentration of the samples obtained by extrapolation.

III. Results and Discussion

Table 2: Results showing the parameters for individual samples in the analysis of Amukachi and Obiudo in Akabo.

Parameters of Water Samples	Sample A Amukachi	Sample B Obiudo	Mean Value	WHO Standard
Colour	44pcu	0pcu	22	Not exceed Hazen 5 unit
Temperature	26.7^{o}C	26.5 ^{o}C	26.6 ^{o}C	Ambient
pH	6.28	5.26	5.77	6.5-8.5
Conductivity	8.1mg/l	11.8mg/l	9.95mg/l	1000µs/cm
Total dissolved solid (TDS)	4.86 mg/l	7.08 mg/l	5.97 mg/l	50mg/l dried at 180

Total suspended solid (TSS)	0.31 mg/l	0.45 mg/l	0.38 mg/l	500mg/l
Calcium hardness	1.41mg/l	1.53mg/l	1.47mg/l	100mg/l
Magnesium hardness	0.26 mg/l	0.83 mg/l	0.545 mg/l	Not mention
Total hardness	1.67 mg/l	2.36 mg/l	2.0 mg/l	500 mg/l
Chloride	0.0 mg/l	0.4 mg/l	0.02 mg/l	75 mg/l
Alkalinity	0mg/l	0mg/l	0mg/l	Not mention
Nitrate (NO_3^-)	0.05 mg/l	0.20 mg/l	0.75 mg/l	50 mg/l
Sulphate (SO_4^{2-})	0 mg/l	0 mg/l	0 mg/l	0.03 mg/l
Phosphate (PO_4^{3-})	0.1 mg/l	0 mg/l	0.05 mg/l	50-60 mg/l

Table 3: Results for the concentration of metal present in the samples in the analysis of Amukachi and Obiudo Village in Akabo

Parameters of Water Samples	Sample A Amukachi	Sample B Obiudo	Mean Value	WHO
K	1.04 mg/l	2.08 mg/l	1,56 mg/l	100 mg/l
Na	0.62 mg/l	0.65 mg/l	0.64 mg/l	200 mg/l
Pb	Not Detected	0.10 mg/l	0.10 mg/l	0.05 mg/l
Cu	0.04 mg/l	0.05 mg/l	0.045 mg/l	0.05 mg/l
Fe	0.99 mg/l	1.20 mg/l	1.059 mg/l	0.05 mg/l
Cr	0.002 mg/l	Not Detected	0.002 mg/l	0.05 mg/l
Cd	0.005 mg/l	0.002 mg/l	0.0035 mg/l	0.01 mg/l
Zn	Not Detected	0.005 mg/l	0.005 mg/l	5.0 mg/l
Mn	0.83 mg/l	0.40 mg/l	0.615 mg/l	0.2 mg/l

III. Discussion

The observation and measurement were made with respect to the physical parameters of the sample when compared with the WHO standard for drinking water.

The appearance of the water sample varied from being clean through milky to being coloured. 5% of the samples exhibited a milk appearance while the remaining 95% of the sample are clear. Colour in the water samples ranges from 0PCU – 44PCU but the specification for WHO standard for drinking water is clear.

The Maximum recommended TSS limit set by WHO is 500mg/1. The mean value of TSS from the drinking water sample was below the standard for WHO.

The total hardness of the sample was below the World Health Organization [6]. The electrical conductivity ranges from 8.1mg/l – 11mg/l. This shows that the TDS value of the samples exhibits properties within the permissible unit of the WHO (2006) guidelines. The correlation coefficient between the electrical conductivity (EC) and the total dissolved solids (TDS) of the sample. This implies that the TDS is basically responsible for the electrical conductivity measured in the water sample, WHO posted that water samples with a TDS level of 600mg/l and less are suitable for drinking. While increasing TDS levels are associated with increasing the non-potability of the water. Based on position, the samples analyzed become increasingly unpotable for drinking at the sampling point.

The result generated from the analysis of calcium and magnesium which ranges from 0.26 – 1.53mg/l is below the WHO standard for drinking water.

The concentration of nitrate range in all the samples falls within the acceptable range standard. The possible sources of nitrate, in this case, are likely to be both anthropogenic (improper sewage disposal near water sources) or by natural means of nitrogen fixation or from agricultural particles (NPK fertilizers).

the SO_4^{2-} in the sample analyzed has the value 0. The concentration of the SO_4^{2-} is within the unit of the WHO standard for drinking water.

The same trend is observed for sulphate in boreholes, they are very low compared to the WHO standard of 250mg/l. The main natural sources of sulphate in the water is the process of chemical weathering and dissolution of sulfur-containing minerals, predominantly gypsum ($CaSO_4.2H_2O$). Oxidation of sulfides and elemental sulfur, and the decomposition of animal and plant residue. Direct anthropogenic sources of sulfate include industrial and municipal wastes, agricultural drainage, and run off. The low values obtained for sulfate suggest that these sources do not contribute a significant amount of sulfate to the water. The sample showed

short variation which ranges from to 0 – 0.1. There was a slightly significant difference. The US EPA does not have any standard regarding the amount of phosphate healthy to ingest in drinking water [7]. Excessive consumption of phosphorus may lead to osteoporosis and poor bone maintenance. Several analysis suggests that a high intake of phosphorous is associated with an increased risk of cardiovascular disease.

The chloride content is also low and within World Health Organization's acceptable standard.

As for iron, it was found at a very high level far higher than the U.S EPA acceptable level of 0.3mg/l total iron content.

Chromium was also detected in the water samples as chromate compounds are used in the school laboratories. Chromium therefore may have entered the groundwater through leaching.

Zinc is present in natural water as a minor constituent. The main industrial use of zinc in galvanizing may affect the water body.

Drinking water that has a high concentration of nitrate is potentially harmful to human and animal health. Nitrate (NO_3) is naturally occurring form of nitrogen (N) which is very mobile in water. the analysis of the sample indicates that non-significant differences exist in the concentration of zinc when comparing the result with NAFDAC and WHO standards for drinking water.

Manganese occurs naturally in many surface waters and groundwater sources and in soils that may erode into these waters. However, human activities are also responsible for much of the manganese contamination in water in some areas.

The presence of heavy metals in drinking water higher than a certain concentration can be detrimental to human health. Therefore, the analysis of heavy metal in drinking water is vital.

The reducing condition found in groundwater and some lake and reservoirs favor high manganese level concentrations up to 1300µg/l in neutral groundwater and 9600µg/l in acidic groundwater have been reported. The National Water Quality Assessment Program data indicate that the 99^{th} percentage level of manganese in groundwater (5600µg/l) is generally higher than in surface water but in the median level in groundwater.

IV. Conclusion

The importance of access to good quality water cannot be over-emphasized. An increase in population coupled with the rise in human activity poses great pressure on the provision of safe drinking water. Effective water quality monitoring could assist in checking how daily activities affect the quality of our water. Generally, the groundwater quality of two communities in Akabo in Imo State is not harmful to human, since the groundwater which was taken from two different communities were analyzed and the analysis showed that the water quality parameters like pH, electrical conductivity (EC), chloride content (Cl), TDS, Ca^{2+}, and Mg^{2+} hardness, lies within the maximum permissible limit as prescribed by WHO. Also, the study revealed that the distribution pattern of the analysis on the physicochemical parameter of the borehole water were within the permissible limit set by World Health Organization. Hence this report explains that the groundwater in the two communities in Akabo is suitable for drinking and agricultural purposes.

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