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DETERMINATION OF THE BIOLOGICAL AND PHYSICO-CHEMICAL PARAMETERS OF BOREHOLE WATER IN OMU-ARAN, KWARA STATE.

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ABSTRACT
The reliance on groundwater for various activities ranging from domestic, agricultural and industrial activities is ever on the increase in developing countries. The groundwater sources will, therefore, need to be evaluated constantly and periodically to ensure its potability and fitness for use. There is little documentation about the quality of water sources in Omu-Aran. This study therefore, is to assess water quality of borehole present in the area. In order to carry out the purported objective of this project, twenty-four samples withdrawn from boreholes of eight different locations across Omu-Aran were taken into consideration. Precautions and standard procedures were taken in its collection, storage and transportation in order to preserve the sanctity of the water samples. The procedures, materials and equipment required to carry out the test for each parameter such as electrical conductivity, dissolved oxygen, pH, nitrate, sulphate, zinc, nickel, E. coli, total coliform etc. were all in line with laid down standards and procedures. Results from the research revealed that the value of analyzed parameters were within the acceptable limits for potable water recommended by World Health Organization and Standard Organization of Nigeria except for iron, nickel, E. coli and pH. Iron, E. coli and nickel were much to above the limit while pH didn't not fall within the minimum and maximum limit allowed. Water quality index and spatial analysis using ArcGIS highlight the significance of these parameters. Borehole water in this region can be considered safe and of good quality but face huge risk of contamination by heavy metals and raises the question of suitability and effect of the drinking in the long run.

***Keywords**: Determination, Biological, Physico-Chemical Parameters Borehole Water, Omu-Aran, Kwara State.*

INTRODUCTION

Water is the source of life and livelihood from cellular to inanimate objects. Its chemical makeup, consists of 2 atoms of Hydrogen covalently bonded with an atom of oxygen, hence it is often referred to as H_2O. The earth is made up of 70%water of whichfreshwater takes 4%. Freshwater is further classified into surface water and groundwater. The distribution of classification of water is uneven with groundwater taking the chunk of 68% and surface boasting 30%. Evidently, the growing rate on the abstraction and exploration of groundwater. This is fast becoming the most common source of water among population with emphasis on the rural population such as the area of Omu-Aran, Irepodun LGA, Kwara State. Utilization of water for domestic, industrial and agricultural activities or purposes are heavily reliant on prevalent and available groundwater resources. Nonetheless, the ever-increasing threat posed to this resource is alarming due to increase in indiscriminate disposal of waste, rapid population growth and density, and mechanization of farming practice.

Water anywhere in the world serves and continues to play and a vital role in the socio-economic development of a country. Surface water is typically used in urban areas due to efficient water treatment processes existing as an effect of being the settlement of the working class and affluent people coupled with the fact that these urban areas are, in most cases, the seat of office. This has created a huge gap between the rural and urban areas. This can be attributed to government's shortcomings and inadequacies in putting the right policies in place to ensure proper water sanitation and even distribution. Despite the creation of the various River Basin Development Authorities (RBDAs in 1978), Water Resource Institute (1977), Federal Ministry of Water Resources (1976), the efforts of government that acted in line with UN's Millennium Development Goals of shortening the population of people with non-access to water by 50% by the year 2015 and also working with the recently implemented Sustainable Development Goals number 6 that states 'Clean Water and Sanitation for all', Nigeria can boast 55% and 22% of urban and rural population respectively access to potable water.

Surface water, in contrast to groundwater, is constantly exposed to pollution and contamination from chemical and physical waste – sewage and refuse – that lead to water borne diseases. Consequently, some per-urban and rural areas have elected to use groundwater as it is free from microbial, heavy metal, physical and chemical contamination. It also possesses the advantage that as water percolates the ground, it goes through some form of filtration and purification by the soil and hence, requires little to no form oftreatment before consumption or use.

Despite the stated fact, a study conducted by WHO reveals that about 1.1 billion people are exposed to the threat of water-borne diseases caused by unsafe water which contributes and is responsible for nearly millions of deaths annually. This is particularly prevalent in developing countries. Also, about 2.6 billion people have been stripped of access to clean, sanitized water worldwide. This underlines the need for maximum protection and sanitation of water and proper treatment of water. Considering the attainment of this feat, children, pregnant, nursing mothers, the elderly and the immune-deficient patients can be less prone to illness and death.

Groundwater resource form season to season, year to year, over the past decade on the meteoric fall from grace Its state gets deplorable as time pass. The causes can be traced to anthropogenic activities and natural processes. Anthropogenic activities include waste disposal facilities, suck ways or latrines, industrial pollution, cemeteries, agricultural agro-allied products etcetera some of which are human induced. Natural processes include dissolution and precipitation of minerals, groundwater velocity, quality of recharge waters and interactions with other types of aquifers. Other factors may include the local geology, hydrology and geochemical properties of aquifer.

In studies related to water quality, assessment of groundwater aquifers with particular reference to boreholes have receive little to no attention. No wonder pollution of groundwater is on an alarming high in response increasing knowledge of the effect to human health (Anazawa, et al., 2004). Groundwater resources are among the most important water sources in Omu-Aran and water is readily in multiple sources which may be safe and available through the year. These sources can be assessed, evaluated and determined by using physical, chemical and biological parameters for quality and suitability.

Potable water is good quality water when taken without any dire consequences free of harmful organism and troublesome color, taste and offensive odor that is aesthetically acceptable (Saleh, et al., 2001). It is for this reason that this study is aimed at evaluating the quality of borehole water in Omu-Aran, Kwara State, Nigeria.

MATERIALS AND METHODS:

This study deals with the description of the research methodology used for the study. It describes the study area, the population and sample, sampling techniques and sampling preparation. It also takes a look at the procedures followed in sample analysis, data collection and analysis.

Description of Area

Omu-Aran is a village in Kwara State at the North Central region of the Federal Republic of Nigeria. It derived its origin from Ife and is currently the headquarters of the local government area of Irepodun. Its geographical coordinates are Latitude 8° 8' 0" North and Longitude 5° 6' 0" East with average elevation of 564m above sea levels. The vegetation of the area, for most part,is Guinea Savannah. Also, the climate is tropical maritime monsoon with about 8 months of heavy rainfall (March to October) ranging 1100mm to 1500mm of rainfall. The annual mean relative humidity, average annual rainfall and average annual maximum temperature are 82.2%, 1262.8mm and 35.8°C respectively.It is nestled in a girdle of hills in the Southern Senatorial District of Kwara State, Omu Aran has a population of 148,600 (2006 census) on a land area of 73.7 square kilometers.

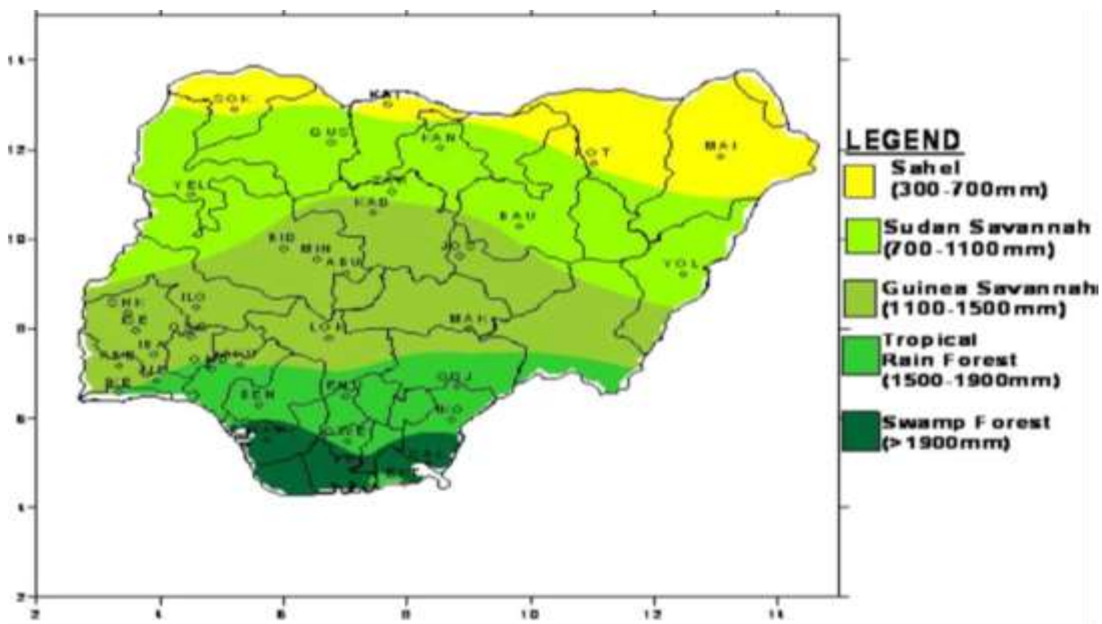


Figure 3.1: Map of Nigeria showing vegetation zones

Geology of the study area

At least 90% of Irepodun LGA is underlain by basement complex rocks of the Precambrian and Cambrian Ages while the remaining parts are underlain with cretaceous and younger sediments. Predominant rock types in this area include:

biotite-granite, granite-gneiss, and meta-sediments that are mainly quartz mica-schist and quartzite. For some places, boulders of laterites overlay the area which screens the underlying geology and sets outs as superficial deposits.

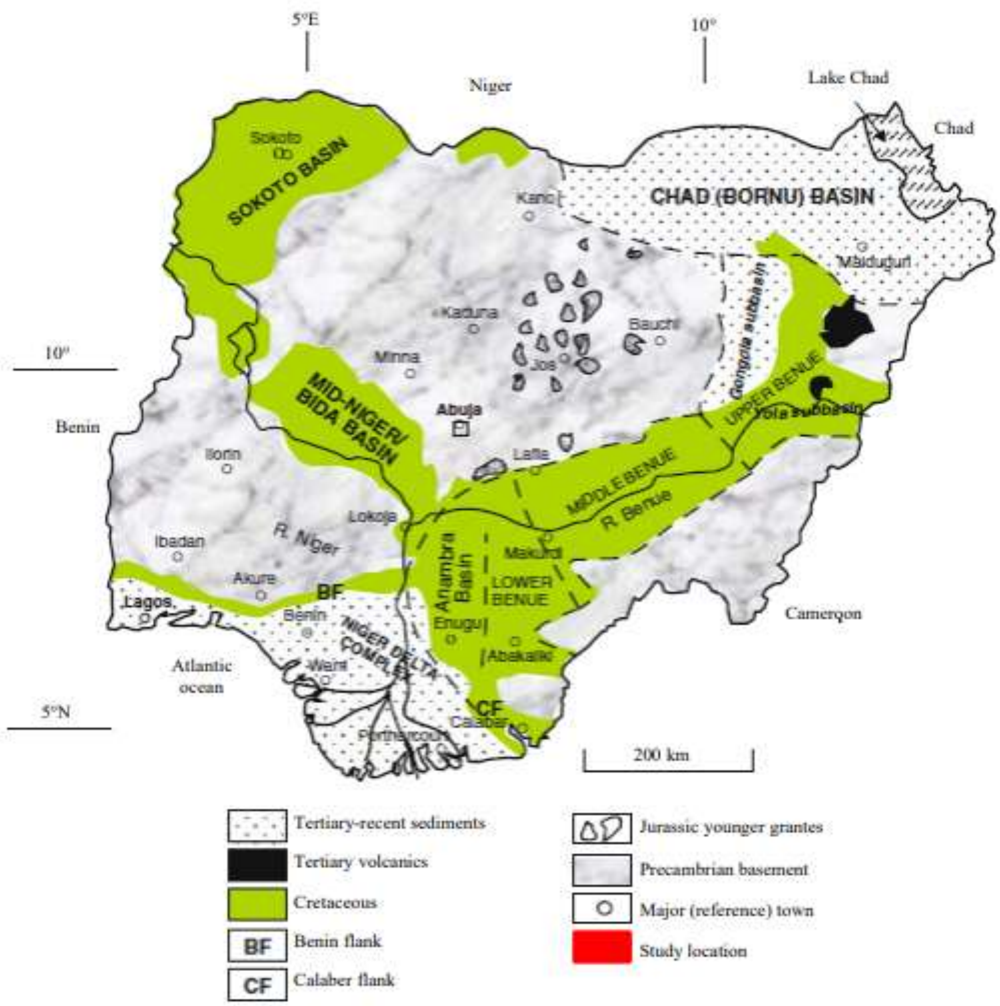


Figure 3.2: Geological sketch map of Nigeria showing study area

Basic amenities such as hospitals and pipe-borne water are unsatisfactorily insufficient. Based on statistics by the National Bureau of Statistics (NBS), 88.7% of Kwara State's population are poor, 41.2% of the households in Irepodun depend primarily on borehole water and 31.2% consume water gotten from wells.(National Bureau of Statistics, 2010).

Sampling Design and Collection

A total of twenty-four samples were collected from across the various selected locations across different parts of Omu-Aran. Samples were collected using pre-sterilized screw capped bottles of 750ml capacity both for physicochemical, microbial and heavy metal analysis. The sterilization process included the use of detergent, diluted HNO_3 and doubly de-ionized distilled water. The acid was used to prevent microbial proliferation. On reaching the point of collection, we allowed the borehole water run for a certain period of time and then followed with a drop in water flow discharge as to allow for easy collection of water and prevent spillage or splashing. We also got rid of gasses from the sterilized bottles by filling and emptying the bottle continually with the water samples. Also, the bottle covers or stoppers were thoroughly washed with distilled water thrice and sample water twice before its actual use. The samples were collected with existing infrastructures. During transport of samples, it was stored or preserved using a refrigerator at 4°C to keep the contents of the bottles or water samples intact before analysis are to be carried out. Water samples collected were evaluated and analyzed using classical and automated instruments or equipment standard method for the analysis of water(American Public Health Association, 2012)

Sample locations

The eight locations for the water collection were identified as this were the only location in Omu-Aran that had boreholes present in them and were willing to allow us draw from their premises. The eight location samples will be identified in the course of this paper with code SL No. The locations where the samples were collected are as follows

SL 1: Omu-Aran Town Hall area
SL 2: Market area
SL 3:GRA King's quarter
SL 4: Bovas/Oko area
SL 5: Winner's chapel
SL 6: Olomu way First bank
SL 7: Liberty area, Redeemed church
SL 8: Aperan area

The image below in the figure represent the point location where samples were collected from across Omu-Aran area.

Figure 3.4: Google Earth image showing the different points of collection and their distribution

Table 1: Coordinates of the different points of collection of samples in Omu-Aran

Point Location	Latitude (°)	Longitude (°)	Altitude (m)
SL 1	8.146689	5.095502	510
SL 2	8.139612	5.105612	528
SL 3	8.136205	5.11045	523
SL 4	8.147277	5.107991	501
SL 5	8.130856	5.108994	506
SL 6	8.13629	5.09939	527
SL 7	8.126007	5.093556	553
SL 8	8.12872	5.089045	545

Laboratoryanalysis

Physicochemical analysis

Color

The method applied to carry out this test is the Colorimetric method. Equipment used is Palin test Photometer 7100 and the consumable used was distilled water.The procedure involve 10ml of distilled water was measured into the Palin test tube. This was used to calibrate or standardize photometer. Then the already measured sample of 10ml was placed in the photometer and the result value was displayed on the screen by selecting ok button on the photometer.

Turbidity

The method applied for this test is the Instrumental method. Equipment used is Digital Turbidity meter and the consumable used is distilled water.

Procedure: Digital Turbidity meter power by electricity is on by press the button on the Equipment. Then the test tube of 20ml of distilled water was placed in the turbidity meter and the nub was adjusted till it's reached zero point on the meter for calibration. Sample filled in 20ml of the same test tube size was placed in the meter and the reading displayed on the screen in NTU unit.

Temperature

Instrumental method was used to carry out the test. Equipment used is the Digital thermometer.

Procedure: The digital thermometer probe was inserted in the sample and reading displayed on the screen. The reading was taking at a stable point.

Dissolved Oxygen, D.O

The method applied to carry this test is the instrumental method. Equipment used is the MW600 Dissolved Oxygen meter and the wash bottle.

Procedure: The Dissolved Oxygen meter was directly inserted into the sample bottle immediately it was brought into the laboratory after transport and measured in mg/L.

Electrical Conductivity

The instrumental method was used in the determination of this parameter. The equipment used include the Multi-parameter. The equipment is turned on and the EC parameter is selected. The equipment is calibrated to zero by inserting the instrument probe into a sample of distilled water. Thereafter, insert the probe into the sample of water to be tested and take the reading displayed on the screen of the equipment as its value.

Total Dissolved Solids (TDS)

The material and method applied in Electrical Conductivity also applies here with a slight difference. The difference is that, after the instrument is turned on, ‘TDS’ will be selected as displayed on the screen.

pH

Instrumental method was used to carry out this test. Equipment used is the pH meter. The procedure includes; the pH meter is first calibrated with buffer solution of 7, 4 and 10. The probe is rinse with distilled water to eliminate any present of acid or alkaline that can affect the value range. Then the probe is inserted into the sample and the result is displayed on the screen.

Chemical Oxygen Demand

The colorimetric method was used to determine the COD value of the water samples. Equipment used includes; the Palin test Photometer 7100, COD Digester, COD safety screen, pipette, COD reagent solution, beakers and tube rack.

Procedures are;

Add two milliliter (ml) distilled water to the COD solution in the COD test tube to prepare blank.

Further add two milliliter of sample water in another COD solution and digest the sample prepared at the temperature of 150^{o}C for two hours.

Blank the Photometer equipment with the solution prepared with the distilled water.

Allow the sample to cool at room temperature and take the reading on the Photometer. The result is displayed as mg/L on the screen.

Chemical parameters

This includes parameters such as Calcium, Nickel, Potassium, sulphate, Nitrate, Aluminum, Copper, Iron, Zinc, magnesium and Chloride. These parameters are carried out under Chemical Analysis test.

Colorimetric method was applied to carry out various test for each parameter. Equipment used includes Palin test Photometer 7100, Palin test tube, crushing stick. Materials made use (which are consumable) include distilled water, latex hand glove, reagents and nose mask/cover.

Reagents were used according to the parameter tested for. Procedure in carrying out the test for each parameter is the same and applicable to all with the only difference being the reagents used for each parameter. Taking for instance, Iron. The procedures followed for the test include;

Fill the test tube with distilled water to the 10ml mark to make blank for the photometer calibration.

Fill another test tube with the sample water to the 10ml mark

Provide one iron tablet (iron's reagent), crush the tablet with a crushing stick and add to the sample and allow to dissolve completely.

Stand the solution for one minute to allow for full color development

Select 'Iron' on the photometer and insert blank to calibrate the Photometer.

Remove the blank and insert the water sample solution, press 'OK' on the instrument and take your reading displayed in mg/L on the screen.

Note: Follow the same procedure for other parameter using their own reagents and selecting their corresponding parameter on the Photometer instrument.

Biological analysis

Total Viable Count

The method used for carrying this test is the Pour Plate method. The material needed to carry out this test includes Nutrient Agar, micropipette, sterile tips, petri dishes, Bunsen burner, 70% ethanol and an incubator.

The procedure or step in carrying out this method include;

1ml of each of the sample was aseptically transferred into a sterile petri dish using 100µl micropipette in duplicate.

The medium nutrient agar in molten state was aseptically poured on the petri dish containing the sample

Allow it to set

Incubate the plates for 24 hours at a temperature of 37ºC.

E. *coli*/Fecal count

The method applied for this test is the Pour Plate method. The materials used in carrying out this test includes Eosin methylene blue agar (EMB), micropipette, sterile tips, petri dishes, Bunsen burner, 70% ethanol, incubator.

The steps involved in this test are as follow;
1ml of each sample was aseptically transferred into a sterile dish using a 1000µl micropipette in duplicate.
The medium which is Eosin methylene blue agar, in molten state was aseptically poured on the petri dish containing the sample and allowed to set.
The plate was then incubated for 48 hours at a temperature of 45^oC.

Coliform count
The method used in this test is the Pour Plate method. Equipment used to carry out this test include micropipette, sterile tips, sterile petri dishes, incubator, MacConkey agar, Bunsen burner, 70% ethanol.
Steps involved in this test includes;
1ml of each the sample was aseptically transferred into sterile petri dish using 1000µl micropipette in duplicate.
The medium that is MacConkey agar in molten state was aseptically poured on the petri dish containing the sample and allowed to set.
The plates were incubated at 37^0C for 24hours.

Heavy Metals Analysis
AA320N ATOMIC ABSORPTION SPECTROPHOTOMETER can be used to measure constant quantity and trace metal element in various samples through atomic absorption analysis and flame emission by flame method, graphite furnace method and hydride method. Graphite cuvette was used for electro thermal atomizer, ultra-high purity acetylene was used as the carrier gas. It works on the principal law of Brown-Bill which is expressed as

$$A = \log\left(\frac{I_o}{I}\right) = KCL$$

Where Io= In-coming light intensity, I = Out-going light intensity =Absorption coefficient, C=concentration of element and L= Distance travelled by light beam through the sample.
The concentration of the sample can be worked out using the above relationship. For this analysis the concentrations were determined from the calibration curve equation. For the analysis of heavy metals using atomic absorption spectrophotometer ((AA320N model)). The samples were analyzed in the

laboratory using standard method (APHA 1992). The heavy metals analyzed in the samples were Lead (Pb), Zinc (Zn), Nickel (Ni) and Copper (Cu).

Procedure

Prepare a diluent (1M Nitric acid):

Dilute 69.75ml Nitric acid (65%) into 800ml of deionized water and mix well by shaking.

Wait and allow to cool the solution at room temperature.

Add enough deionized water to make 1000ml.

Preparation of 0.1 (mg/L=ppm) Stock Solution of Metals: Stock solutions were prepared by dissolving specific number of salts of Lead (Pb), Arsenic (As) and Cadmium (Cd).

Take 80ml of 1M Nitric acid solution into a clean and dry volumetric flask of 100ml.

Add 10 microliter (μL)salt (using micropipette) standard of 1000 ppm into (i) above and mix well by shaking, then fill to 100ml by adding 1M Nitric acid solution into volumetric flask.

Store and allow to cool until it is ready for use

Repeat the procedure for (0.2,0.4,0.6,0.8 and 1.0 mg/L)

Instrumental analysis

Calibration and Sample Reading: Working standards (0, 0.2, 0.4, 0.6, 0.8 and 1.0 mg/L) solutions were prepared from the stock solution and treated appropriately as for sample and absorbance read. The readings were used to prepare calibration graph. The sample and blank solutions were measured at wavelength for specific metal using atomic absorption spectrophotometer (AA320N model). The absorbance of blank was subtracted from absorbance of sample. The result was read from the graph and concentration of heavy metal was reported in mg/L.

Figure 3.5: AA320N model of Atomic Absorption spectrophotometer

Water quality index determination

Most effective tool to monitor the surface as well as groundwater pollution is the water quality index which can be used efficiently in improving the water quality programs. Water quality index gives information on a rating scale from zero to hundred. Ten parameters were performed to designed the water quality index. T

In present study, three steps of water quality index are defined by Hameed, Alobaidy, Abid, and Mau loom (2010). In the first step each of the nine parameters (Calcium, pH, Dissolved Oxygen, Iron, Lead, COD, Nickel, Nitrate, Total Dissolved Solids, Total Coliform) have been assigned a weight (w_i) according to its relative importance on the comprehensive quality of water which range from 1 to 5.

In the second step, relative weight (k) is computed from the following equation

$$k = \frac{1}{\sum_{i=1}^{n} \frac{1}{S_i}}$$

where W_i and w_i is the relative weight and weight of each parameter respectively and total number of parameters is n.

In the third step, quality rating scale (q_i) for each parameter were computed by dividing its standard concentration

$$Q_i = (c_i / s_i) * 100$$

where q_i is the quality rating scale, the concentration of each chemically parameters is ci in each water sample in mg/l, s_i is the standard concentration of the parameter as provided by WHO or SON. For calculating water quality index, the Sl_i is first determined for each chemically parameters which was calculated by the following equation

$$W_i = (K / S_i)$$

$$WQI = \sum_{i=1}^{n} W_i Q_i / \sum W_i$$

where, the sub index of i^{th} parameters is Sl_i, the rating of each concentration of i^{th} parameters is q_i, and the number of parameters is n.

Calculated water quality index was classified into five groups excellent water to water unsuitable for drinking of range water quality index for drinking purpose provided in the below

Table 2: Classification of water using WQI

Range of Water Quality Index for drinking purposes		
S. No	Range	Type of water
1	0-25	Excellent
2	26-50	Good
3	51-75	Poor
4	76-100	Very Poor
5	>100	Unsuitable for drinking purposes

Spatial analysis

Spatial analysis is used to solve complex location-oriented problems, find patterns, assess trends and make decisions. A GIS software was used to map, query and analyze the data in this study. Specifically, ArcGIS was used for generation of various thematic maps and the groundwater quality map. Ordinary kriging which is an interpolation technique was used to obtain the spatial distribution of water quality parameters. The kriging method was chosen because it works best when the data are normally distributed(Nas & Berktay, 2009) Therefore, for each quality parameter, an analysis map was created.

RESULTS AND DISCUSSION

This study presents results of the study in line with the objectives under different subheadings. The background information on water quality including; The water quality index used in evaluating the water quality was also presented and finally the spatial representation of groundwater quality across sampling points were presented.

Physico-chemical parameters

According to (Freeze & Cherry , 1979) classification, the groundwater in the study area can be described as freshwater owing to the fact that in all eight locations, values obtained are less than 1000mg/L (TDS<1gL^{-1}). The total dissolved solids concentrations varied from 11.9mg/l to 96.9mg/l. These results show that the samples contained very small dissolved particles with its turbid values at 0 NTU. Turbidity is not a parameter that has direct health impact but can harbor microorganisms that can protect harmful substances and reduce the effectiveness of water treatment process. Consequently, the color was found to be absent in the samples with their values at 0mg/l, which is very much below the limit of 15mg/l set by WHO.

Furthermore, their pH values discloses that they are acidic in nature (<6.5) and they do not meet the permissible limit for pH with the values varying at 6.5-8.5. This could lead to gastrointestinal irritation and would need alkaline treatment to improve the pH levels to meet the minimum standards set by WHO. Although, non-treatment will not adversely affect the health of the locals living in the area. However, alkaline water poses more benefits to the body than regular water. Such benefits include aid in digestion, acts as a laxative etc. Deviations in pH could be mainly caused by the geological formation of the area, hydrolysis of salt of weak acid and strong bases or vice versa as well as dissolved gases present in the water. The electrical conductivity of the water samples is very much below the maximum permissible limit of 1000µS/cm with average range between 23.7 and 192.1. This is also a ratification of the groundwater's freshwater nature as all values for all location samples were below the permissible limit according to (Mondal, et al., 2008). The COD levels are well below the permissible limit of 250mg/l. From the results obtained, little oxygen is required to oxidize any organic matter present. The Dissolved Oxygen levels for the water samples were within the permissible limit of 4 by WHO and 7.5 by SON. The low DO levels indicate low organic pollution. Due to this fact, such values can be brought down to the nearest minimum by properly constructing the boreholes and avoid pollution around its area. Temperature of the samples ranged between 17.3ºC in sample location 1 to 27.9ºC in sample location 2.

Table 3: Physical parameter of study area

Location	Turbidity	Color	DO	EC	TDS	Temp	COD	pH
Sample 1	0	0	3.05	52.4	27	22.4	2	5.43
Sample 2	0	0	3.8	192.1	96.04	27.8	4.3	5.21
Sample 3	0	0	3.43	30.1	15.5	25.9	4.3	5.86
Sample 4	0	0	3.23	126.7	63.4	25.07	5.3	5.94
Sample 5	0	0	3.3	50.1	25.1	25.4	4	5.57
Sample 6	0	0	3.8	171	85.6	25.5	2.7	5.69

Sample 7	0	0	3.2	28.2	14.8	22.4	2.7	5.2
Sample 8	0	0	3.5	23.7	12	25.5	3	5.28

Chloride (Cl^-)

Residual chlorine was not found (0.00mg/l) in any borehole water sample which are below the limit of stipulated by the WHO (250mg/l). Meanwhile, the concentration of Cl^- ranged between 2.0 and 37.0mg/l. The prolonged intake of chlorine, as of present, does not have any observable effect on the body but residual chlorine could offset the production of free radicals in the body that could damage the cells leading to cancer. Low chloride concentration in the body could also lead to hypochloremia, dehydration and loss of fluids since it is an electrolyte that balances acid and base in the body

Nitrate (NO_3^-)

The maximum nitrate concentration was found in sample location 1 with value of 2.2mg/l and the least nitrate concentration was found at sample location 7 with value of 1.92mg/l. Evidently, the values of concentration were below the permissible limit stipulated by WHO. This information shows how far off the boreholes are from sewage and other waste rich with nitrate concentration. Nitrate concentrations are sometimes common in groundwater where there is a close proximity to animal and human waste, sewage systems or open septic and fertilization of farm.(Akaahan, et al., 2010).

Sulphate (SO_4^{2-})

According to the results gotten from the experiment, the least concentration of sulphate discovered in location 8 was 10mg/l and the highest concentration of sulphate was discovered in location 5 with a concentration of 23mg/l. The different sulphate concentration gotten from the different locations are lower that the permissible limit of sulphate stipulated by WHO which is 100mg/l, this information portrays how far away the borehole is from farm activities and animal waste that could add sulphate to the borehole water.

Potassium

A very vital mineral for the body. Potassium, like many other things, have its disadvantage for its excess intake and deficiency. These effects are, however, short-lived and curable for instance cramps, weakness, nausea, vomiting, constipation etc. Moreover, its importance cannot be overemphasized and there include help in regulation of muscles contractions, fluid balance and nerve signals. All the results of the samples were below 12mg/l set by NSDWQ.

Calcium (Ca^{2+})

Calcium in our body acts as muscles contraction, blood clotting, vascular contraction and nerve transmission (Saleem, et al., 2016). Taking a lower amount of calcium has been associated with increased risk of osteoporosis, hypertension, colorectal cancer, coronary artery diseases, obesity, insulin resistance and nephrolithiasis. Also, excessive high content of calcium should be avoided in water to reduce the occurrence of bladder stone or kidney stone. The highest value of calcium concentration was observed to be 114mg/l at sample location 1 while the lowest concentration was at 28.7mg/l in sample location 6. In all, the values were less than the maximum permissible limit of 200mg/l by WHO.

Magnesium

It has been discovered that the lack of magnesium in the human body contributes to the heightened risk of hypertension, vasoconstrictions, atherosclerotic vascular disease, cardiac arrest, eclampsia in pregnant women, acute myocardial in infection and osteoporosis etc. Magnesium concentration above allowable limit by WHO (>100mg/l) could lead to neurological disorder and may have a laxative effect. High concentration shows the source's proximity to rocks and minerals with a high level of limestones and gypsum. Comparing with the permissible limit stipulated for magnesium concentration by NSDWQ (20mg/l), it is discovered that both the maximum concentration of magnesium found in location 1 (18mg/l) and the lowest magnesium concentration found in location 8 (8mg/l) were lower than the permissible limit. This shows that the area is not rich in limestone and gypsum.

Manganese

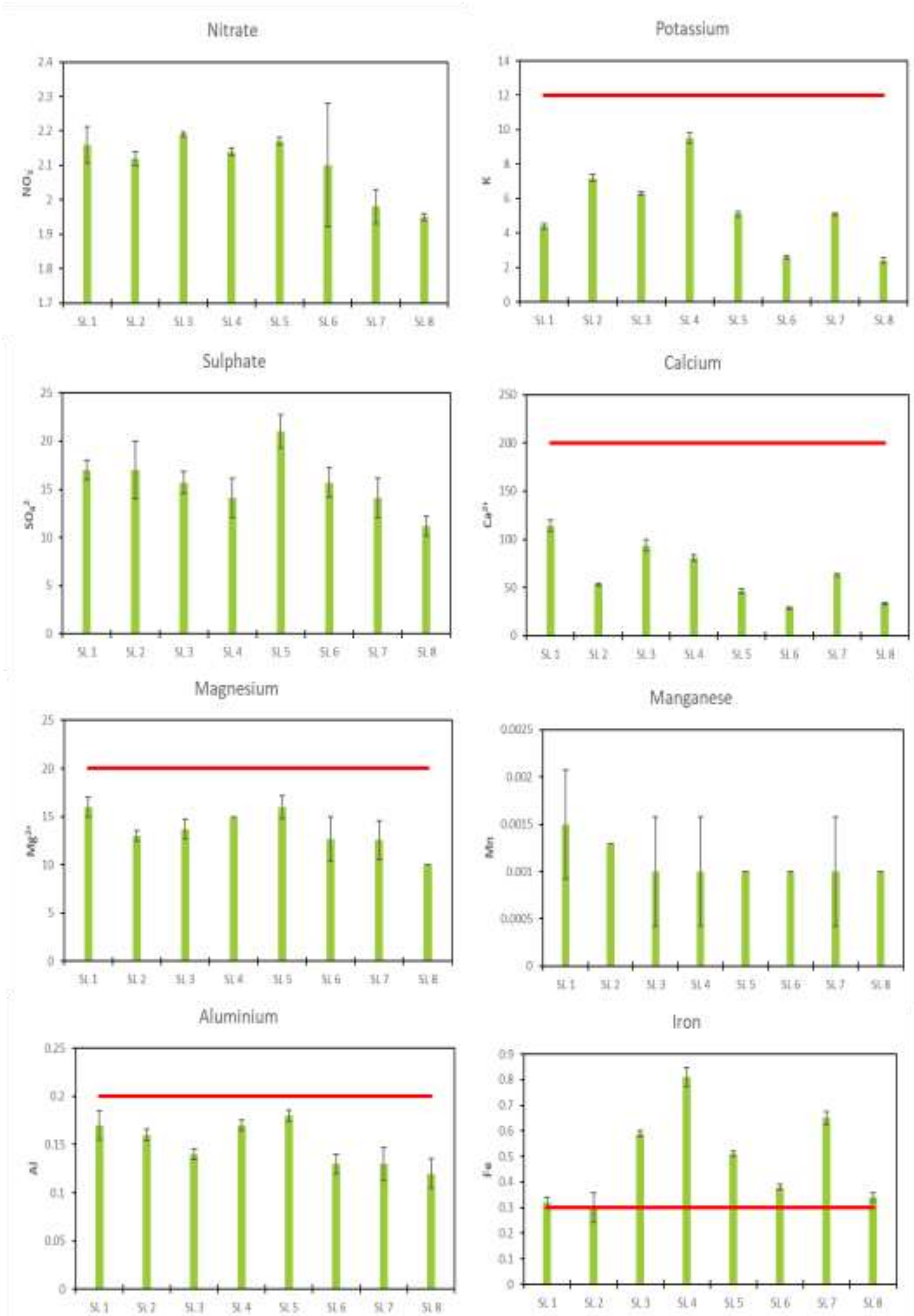
Diseases that occur as a result of lack of manganese in the body includes pneumosclerosis, cartilage growth disturbances, anthroncus and soft bone as well as manganese related madness(Shu, et al., 2011). The presence of manganese proves the contribution of naturally occurring weathered manganese bearing rocks and minerals around its vicinity. It may also be through the contribution of sewage and landfill leachate, industrial waste and/or acid-mine drainage. Results from the testing shows that the minimum manganese concentration discovered was 0.001mg/l and the maximum concentration discovered was 0.002mg/l. Comparing with the permissible limit of manganese stipulated by WHO (0.2mg/l), it was discovered that the concentration of manganese found in the boreholes were lower than the stipulated value of manganese.

Iron

High concentrations of iron intake through water can lead to hemochromatosis, that is, damage to the heart, liver and pancreas. Iron is very important to the body for hemoglobin production, nonetheless it has to be taken in minute quantities. However, the deficiency in iron intake can have adverse effect particularly in infants and children. Deficiency in iron minerals can lead to iron anemia meaning insufficient production of hemoglobin and hence insufficient intake of oxygen. According to results from the test, all location samples were above the permissible limit set by both SON and WHO (0.3mg/l). These results show that the borehole water samples are within iron bearing rocks and minerals, industrial waste, sewage and landfill leachate.

Aluminum

This is the most abundant metal on the earth crust; therefore, it is natural to find traces of its molecules in water. Nonetheless, it should not be taken in high amount since it has been related to many brain diseases including Parkinson's disease, Alzheimer's disease and multiple sclerosis. This could mean it has a cumulative effect on lifetimes after. In addition, it is controversial on its relation to potential neuro-degenerative disorders. According to the results, all samples in each location were less than the maximum permissible limit by NSDWQ (<0.2mg/l).



Heavy metals

Zinc

The minimum concentration of zinc was found in sample 8 with a value of 1mg/l and the maximum zinc concentration was discovered in both sample 1 and 4 with a value of 2.2mg/l. According to the permissible limit stipulated for zinc which is 3mg/l, it is discovered that the zinc values found are lower than the stipulated zinc concentration.This information indicates that the boreholes are far away from activities that induces zinc into the borehole like production of steel.

Nickel

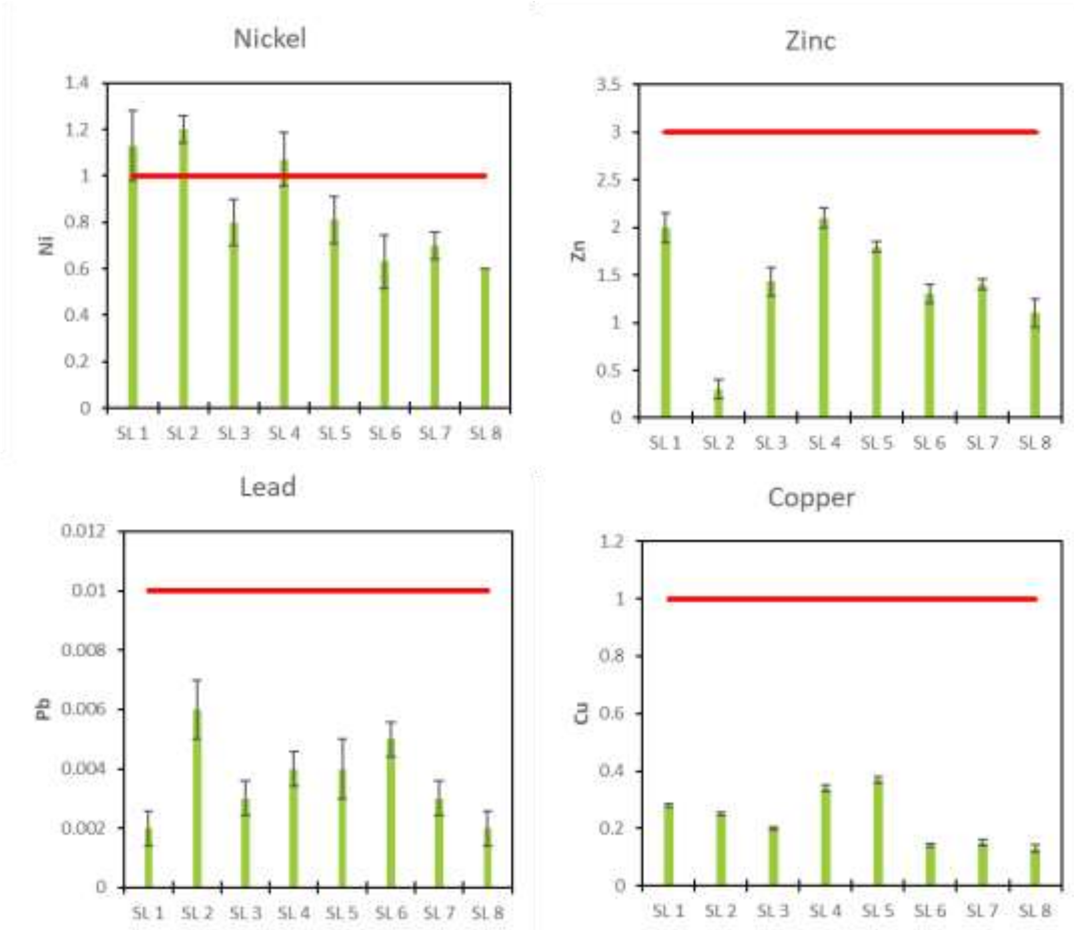
The primary source of nickel in water is attributed from the leaching of metals in contact with drinking water. Secondary sources could be as a consequence of dissolution of nickel-ore rocks and minerals. Excessive intake can be very detrimental to the human health. It increases the potential of cancer (because it’s carcinogenic), allergy, lung fibrosis etc. The values of nickel concentration were all above the permissible limits (>0.02) by SON and WHO, with the minimum value being 0.5mg/l at sample location 6.

Copper

The maximum value for copper was observed to be 0.37mg/l at sample location 5 and the lowest value for copper was also observed to be 0.13 at sample location 8. Evidently, these values were below the limit set by SON which stands 1mg/l. Higher content of copper in water would lead to gastrointestinal disorder and raises the sensitivity of those with the Wilson’s disease.

Lead

The presence of Lead (Pb) in borehole could be of health significance. The maximum mean value of copper was found to be 0.006mg/l at sample location 2 while minimum mean value for lead was found to be 0.002 at sample 1 and 8. The health impact it could cause covers cancer, inference with Vitamin D metabolism, toxic to the central and peripherous nervous system, affects mental development in infants.(Sojobi, et al., 2014) reports that high dosage of Pb could lead to miscarriages in pregnant women and could damage the male reproductive organ. However, the values were below 0.01mg/l making it acceptable as given by SON.



Microbial parameters

*E. coli/*Fecal coliform

E. coli is one of the most specific indicators that there is fecal pollution of water than any other fecal coliform. Zero coliform forming unit was recommended by both SON and WHO in any 100ml of water. The minimum mean value of E. coli was observed to be 0.3mg/l in sample location 8 and the maximum mean value was found to be 1.3 cfu/ml at location 2. All sample locations were all observed to be higher than the permissible limit. This could be due to the fact that the boreholes were poorly construction because from visual observations, there was considerable distance between boreholes and septic tanks. Below show the table for results obtained.

Table 4: Showing the distribution of E. coli in the study area

Location	Mean ± SD	Range
SL 1	0 ± 0	0
SL2	1.3 ± 0.1528	1.1-1.14
SL 3	1.1 ± 0.108	1-1.2
SL 4	0.7 ± 0.6083	0-1.1
SL 5	0.67 ± 0.5774	0-1
SL 6	0.33 ± 0.5774	0-1
SL 7	0.7 ± 0.5774	0-1
SL 8	0.3 ± 0.5774	0-1

Total Coliform count

The maximum mean value for total coliform count was found to be 1.27 cfu/ml at sample location 3 and the minimum value at location 8 to be 0.3mg/l. This is much lower than the permissible limits of 10mg/l by SON. This does not necessarily mean that fecal pollutants are not present in the water but it could mean also the presence of non-fecal coliforms.

Table 5: Showing the Total Coliform count for the different locations in study area

Location	Mean ± SD	Range
SL 1	1.1 ± 0.1528	1-1.3
SL2	1.3 ± 0.1155	1.2-1.4
SL 3	1.27 ± 0.0816	1.2-1.4
SL 4	1.23 ± 0.1528	1.1-1.4
SL 5	0.33 ± 0.5774	0-1
SL 6	0.67 ± 0.5774	0-1
SL 7	0.7 ± 0.5774	0-1
SL 8	0.3 ± 0.5774	0-1

Total Viable Count

The total viable count is also a specific indicator of the number of live cells capable of growing into colonies (ref). According to results, sample location 2, 3, 4, 6 and 8 has live cells present in the capable of growing into colonies.

Table 6: Showing total viable count of different locations in the study area

Location	Mean ± SD	Range
SL 1	0± 0	0
SL2	1.1 ± 0.1	1-1.2
SL 3	1 ± 0.0707	1-1.1
SL 4	0.3 ± 0.5774	0-1
SL 5	0 ± 0	0-0
SL 6	0.33 ± 0.5774	0-1
SL 7	0 ± 0	0-0
SL 8	0.7 ± 0.5774	0-1

Water Quality Index (WQI)

The computation of the water quality index is given as

Table 7: Showing the method of computation for WAWQI

W. A. W. Q. I						
	Standard (WHO)					
Parameter	Min	max	Ideal	1/S	K	Wi
Fe		0.3	0	3.33333	0.0065	0.02168
COD		250	0	0.004	0.0065	2.6E-05
DO	5		14.5	0.2	0.0065	0.0013
PH	6.5	8.5	7	0.11765	0.0065	0.00077
TDS		500	0	0.002	0.0065	1.3E-05
Calcium		200	0	0.005	0.0065	3.3E-05
NO_3		50	0	0.02	0.0065	0.00013
Ni		0.02	0	50	0.0065	0.32514
Pb		0.01	0	100	0.0065	0.65027
TC		10	0	0.1	0.0065	0.00065

In order to overview the quality of water for drinking and other purposes, we utilize the chemistry of groundwater as a measure. In the computation of results, the addition of nickel in the calculation brought a lot of complications. In order to circumvent around the problem, two tables will be produced to show the values of the Water Quality Index with and without the nickel parameter. The calculated water quality indices without the nickel parameter for the different borehole water samples are presented below

Table 8: Showing the water quality indices of the different locations in the study area

Sample Locations	W. Q. I	Quality	Possible usage
SL 1	24.72	Excellent quality	Drinking, irrigation and industrial
SL 2	24.83	Excellent quality	Drinking, irrigation and industrial
SL 3	24.79	Excellent quality	Drinking, irrigation and industrial
SL 4	34.48	Good quality	Irrigation and industrial
SL 5	44.09	Good quality	Irrigation and industrial
SL 6	53.64	Poor quality	Irrigation
SL 7	24.95	Excellent quality	Drinking, irrigation and industrial
SL 8	24.82	Excellent quality	Drinking, irrigation and industrial

The calculated water quality indices with the nickel parameter for the different borehole water samples are presented below

Table 9: Showing the water quality indices of different location in study area with nickel

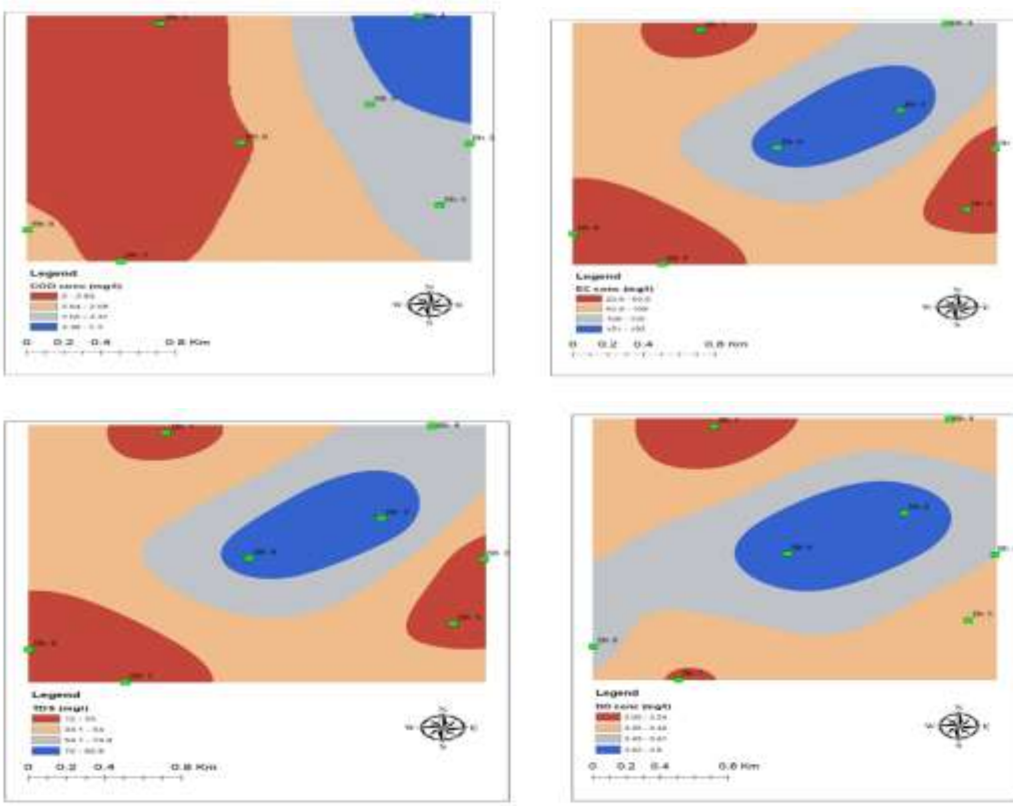
Sample Locations	W. Q. I	Quality	Possible usage
SL 1	1658.64	Unfit for drinking	Proper treatment required before use
SL 2	1993.56	Unfit for drinking	Proper treatment required before use
SL 3	1408.27	Unfit for drinking	Proper treatment required before use
SL 4	1648.89	Unfit for drinking	Proper treatment required before use

SL 5	1330.26	Unfit for drinking	Proper treatment required before use
SL 6	1011.58	Unfit for drinking	Proper treatment required before use
SL 7	1073.48	Unfit for drinking	Proper treatment required before use
SL 8	992.13	Unfit for drinking	Proper treatment required before use

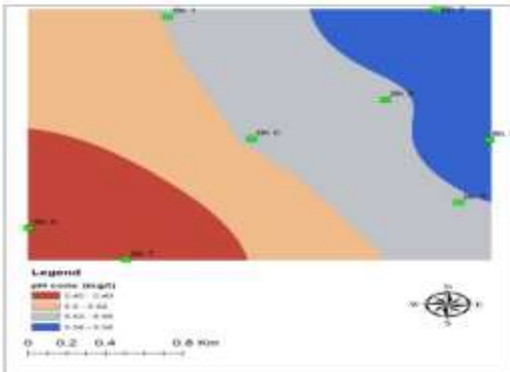
Spatial analysis

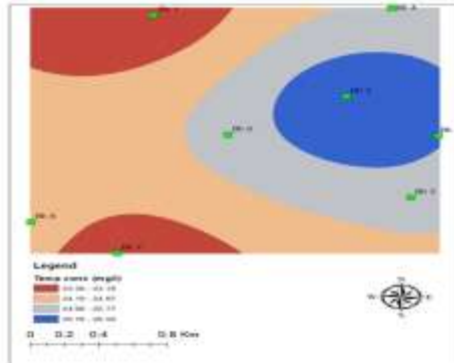
Physical parameter spatial analysis

These are the spatial distribution of physical parameters in Omu-Aran.



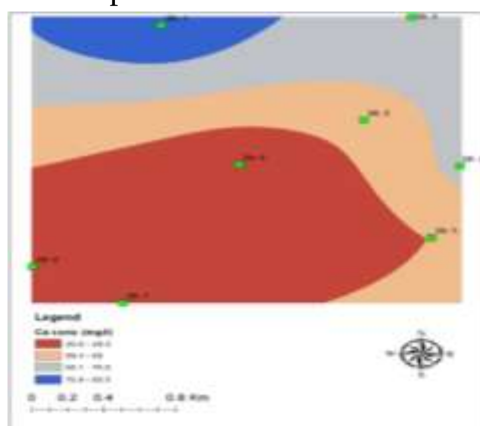
Vol. 24 No.5
March, 2022.

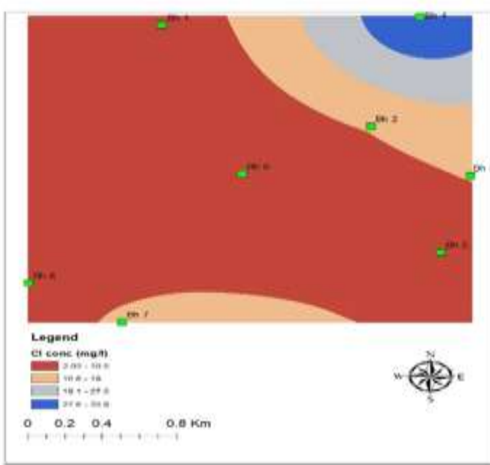


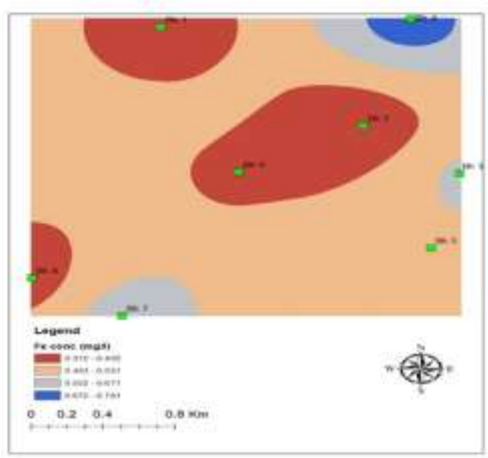


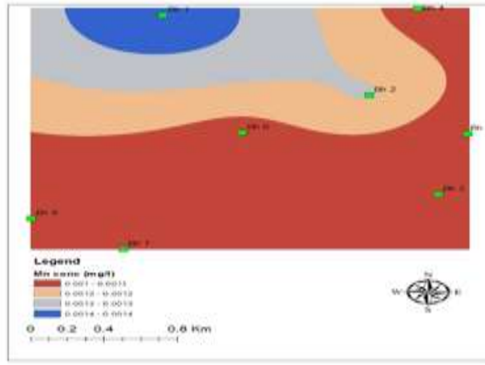
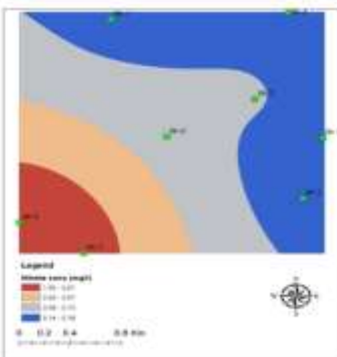
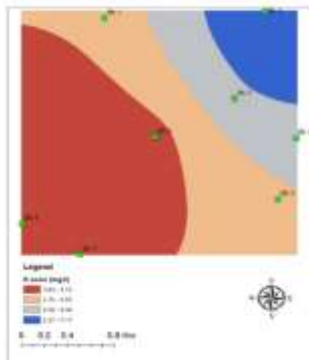
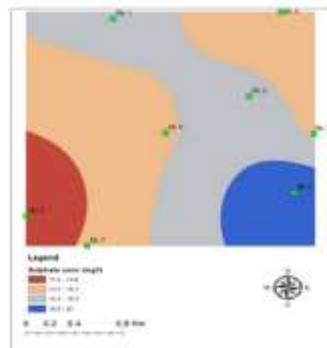
Chemical parameter spatial analysis

Below is the spatialdistribution of some chemical parameter



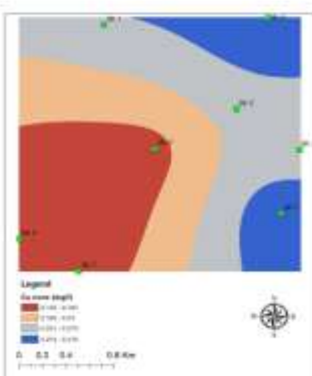
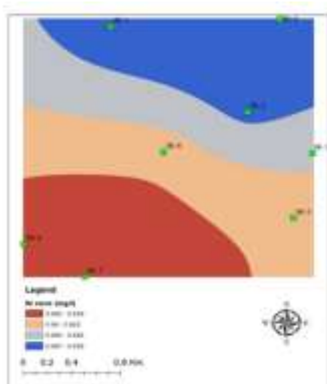
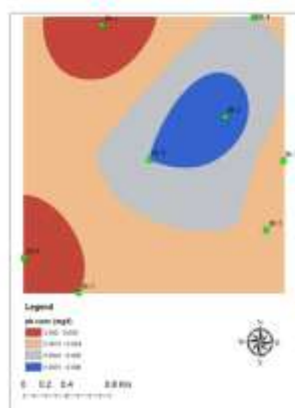




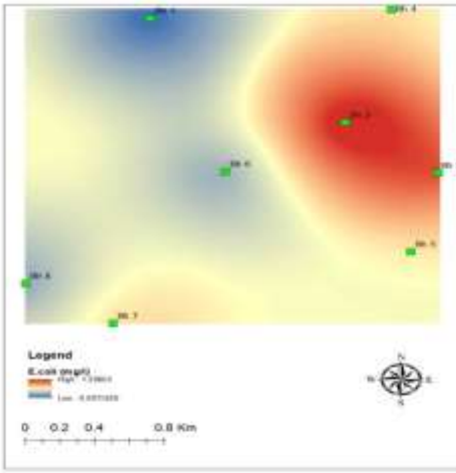
Heavy metal spatial analysis

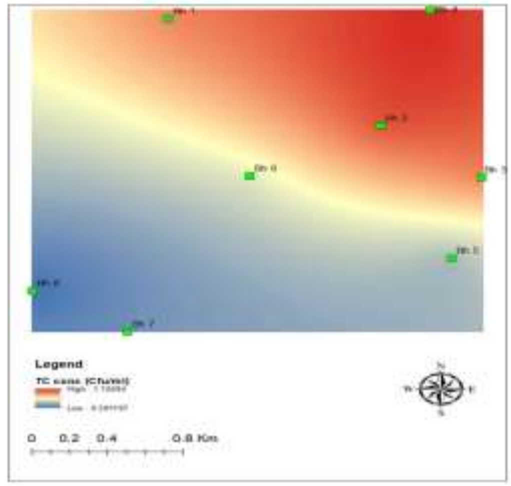
Below are the images of the spatial distribution of heavy metal such as copper, nickel and lead.

Biological parameter spatial analysis

Below is the spatial distribution of *E. coli* in the area





Summary

Groundwater is the most important source of the domestic, agricultural and industrial supply in the world. Chemical and microbiological activities are the major threats to the effect of total dependence on groundwater as a source of drinking water. As groundwater comes into contact with ore-bearing rocks, dissolution of elements into the water course occurs. Groundwater development in Nigeria is further hampered by improper disposal of hazardous and solid wastes, leakage of underground storage tanks and seepage of agrochemicals from agricultural farms.

Due to the high pollution of most of the surface water in Nigeria, groundwater is now preferred to surface water. Nigeria, not excluding Omu-Aran is densely populated due to migration of people from the rural areas and various regions to seek greener pastures, the conventional water treatment facility thus, cannot meet the potable water demands of residents, Individuals have therefore resorted to developing their own water supplies form groundwater resources through drilling of individual boreholes, as in the case of Omu-Aran (study area). Pollution of groundwater has become alarming in response to increasing knowledge on their effect to human health(Anazawa, et al., 2004)

This research study was conducted to assess the quality of these private boreholes and to determine the water quality index.

The research conducted in Omu-Aran community revealed that water from the boreholes sampled were slightly acidic with no exceptions. All water samples analyzed were observed to be freshwater since their corresponding values of Total Dissolved Solids were less than 1000mg/l.

Relatively low concentrations of inorganic constituents were found from the boreholes from the study area. Generally, the values of the chemical parameters were below maximum allowable limits according to WHO, SON and NSDWQ. The relative abundance of the major anions and cations in the boreholes were Cl^{-}>NO^{3-}>SO_4^{2-} and Ca>Mg>K>Zn>Al>Pb>Mn respectively

Furthermore, traces of heavy metal were discovered in the water samples with nickel posing more serious threat as it surpassed the permissible limits set by SON. The rest of the heavy metals conformed to the guidelines set by SON and WHO.

In addition, the values of E. coli are well above permissible limits showing the presence of fecal pollution from the boreholes water samples. Certain water sample showed no signs of active cells and all water samples were below limits set by guidelines of SON for total coliform present.

From the results computed for water quality index, 100% of water samples are of good quality.

Conclusion

The groundwater samples tested are evidently freshwater with no threat of saline intrusion. The research study conducted in Omu-Aran community revealed that all of the groundwater samples analyzed were found to contain minimal physico-chemical parameters with no exceptions.

From observations, the location of the boreholes was situated away from septic tanks. Unfortunately, some locations were found to be highly contaminated for *E. coli*. It will therefore require treatment before use by either boiling or hypochlorite solution to kill most of the bacteria.

Iron concentration was found to be high. Iron is a major component of borehole probably originating from parent rocks. That is to say, the groundwater are affected by dissolution of materials.

Water quality indices shows that water samples from the locations 5 and 6 are of good quality, sample location 1, 2, 3, 4 and 8 are of excellent quality and only location 7 show water of poor quality according to our scale. These indices were computed without the nickel parameter. With the nickel parameter, all water samples were unfit for use and required treatment before use.

Spatial analysis is used to show the relationship between parameter dataset and water quality within the Omu-Aran community. The ArcGIS was used to activity and showed its capabilities in water quality assessment.

Lastly, the surrounding play a role in contaminating available water sources especially its microbial quality. The related health risk becomes even more important as majority of residents depend on borehole for daily domestic use.

RECOMMENDATIONS

1. Further research should be conducted to ascertain the reason for relatively high values of Nickel for all boreholes
2. Local authorities should ensure strict adherence to the proper construction, utilization and maintenance of boreholes.
3. Public health sensitization should be intensified in the community to help maintain good sanitation practices around the boreholes
4. Further research should be conducted to determine the correlation between these parameters.
5. A closer scrutiny should be given to the reason behind the high concentration of E. coli

1.1

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