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ASSESSMENT OF THE HYDROGEOCHEMISTRY OF THE GROUNDWATER RESOURCES OF GWOZA, NORTHEASTERN NIGERIA

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ABSTRACT

The study was carried out in Gwoza town of Borno State to assess the chemistry of groundwater of Gwoza Local Government. Eighteen (18) groundwater samples were collected for the purpose of this study; samples were analyzed for their physical parameters at spot using field kits combined pH/EC/TDS/Temperature meter model Mi 806 were also used for measuring physical parameters. GPS was used in locating the sampling points. Sodium and Potassium were analyzed by flame photometry method; Calcium and Magnesium were determined by Atomic Absorption Spectrometry method using AAS-400 PerkinElmer model type. Iron was determined using spectrophotometer, Photometric method was used to determine sulphate while chloride was analysed using argentometric of bicarbonate HCO_3^- and carbonate CO_3^{2-} . From the result obtained Na^+ range from 26-200 mg/L, K range from 7 – 59 mg/L, Ca^{+2} range from 45- 290 mg/L, Cl^- range from 20 – 264 mg/L, HCO_3^{2-} range from 120.06 - 292 .9 mg/L, NO_3^{2-} range from 14 – 670 mg/L, SO_4 range from 0 – 79 mg/L, Fe^{2+} range from 0.08 – 0.44 mg/L, Mn^{+2} range from 0.00 – 0.20 mg/L and Mg^{2+} range from 0.45 – 1.95 mg/L. The results of the analyses were compared with the WHO standards of drinking water indicates that Cl^- and NO_3^{2-} in some locations are above the permissible limit while all other elements are within the set standard. Therefore the water is not safe for drinking and bacteriological analysis is recommended for the area.

Keywords: Atomic absorption spectrometry, Flame photometry, Groundwater, Gwoza .

INTRODUCTION

Groundwater today is regarded as a very important source of water supply throughout the world. Its increasing demand for irrigation, industries, rural and municipal consumption cannot be over emphasized. As groundwater is hardly chemically free, solution of substances takes place in the source of infiltration and percolation through rocks, hence require changes in chemical composition in which some part may be alkaline and some acidic. The different composition of chemical element in groundwater determines its harmfulness or suitability for uses (Kumar, 2010). However, as greater development and uses of this indispensable resource continues, combine with re-use of water, quality suffers unless consideration is given to protect it. The study area is underlined by Precambrian Basement Complex rock. It is situated within the Sudan Savannah vegetation type with a typical wet season and dry season and moderate rainfall. The rainy season usually starts in March and terminates in October, while the dry season begins in October and ends in February with an annual rainfall of 743 mm and temperature of

33°C is experienced in Gwoza area (Adamu *et. al.*, 2012).

Barber, (1962) also analysed the chemical quality of groundwater from the basement complex rocks of Gwoza and the result showed that the groundwater of the area is suitable for domestic and agricultural uses. Adamu *et.al.*, 2012 assess the chemistry of the major ions in the groundwater in Gwoza and concluded that all the ions are within WHO (1996) and fit for both human and animal consumption. The quality of groundwater is determined by its chemical composition of precipitation, mineral composition of aquifer and confining beds through which the water moves (Aminu and Amadi, 2014). Furthermore, groundwater is the primary and reliable source of portable water in most parts of Nigeria. However, the reliability of these precious and vital resources is under increasing threats from surface anthropogenic activities related to uncontrolled urbanization, incessant waste disposal and poor land use management (Galadima *et.al.*) The aim of this research is to undertake an assessment of hydrogeochemistry of the groundwater resources of Gwoza town.

Geology of the study area

The study area is located between latitude 11°09'1 and 11°14'N and longitude 13°40'14' and 13°49'E and occupies an area of 196 km² within Borno State in the north eastern part of Nigeria (Fig.1). The geology of area is composed of two prominent geologic units. These are the Undifferentiated Basement Complex and the Older Granite. The oldest of these units is the

Undifferentiated Basement Complex. The Undifferentiated Basement Complex (2800 ma) constitutes principally the igneous and metamorphic rocks of pre Cambrian Age (Grant, 1971). These include the Granites, Gneisses and Migmatites. The migmatites gneiss occurs as banded gneiss characterized by alternating light (leucosomes) and dark (melasomes) bands of feldspathic and biotitic materials.

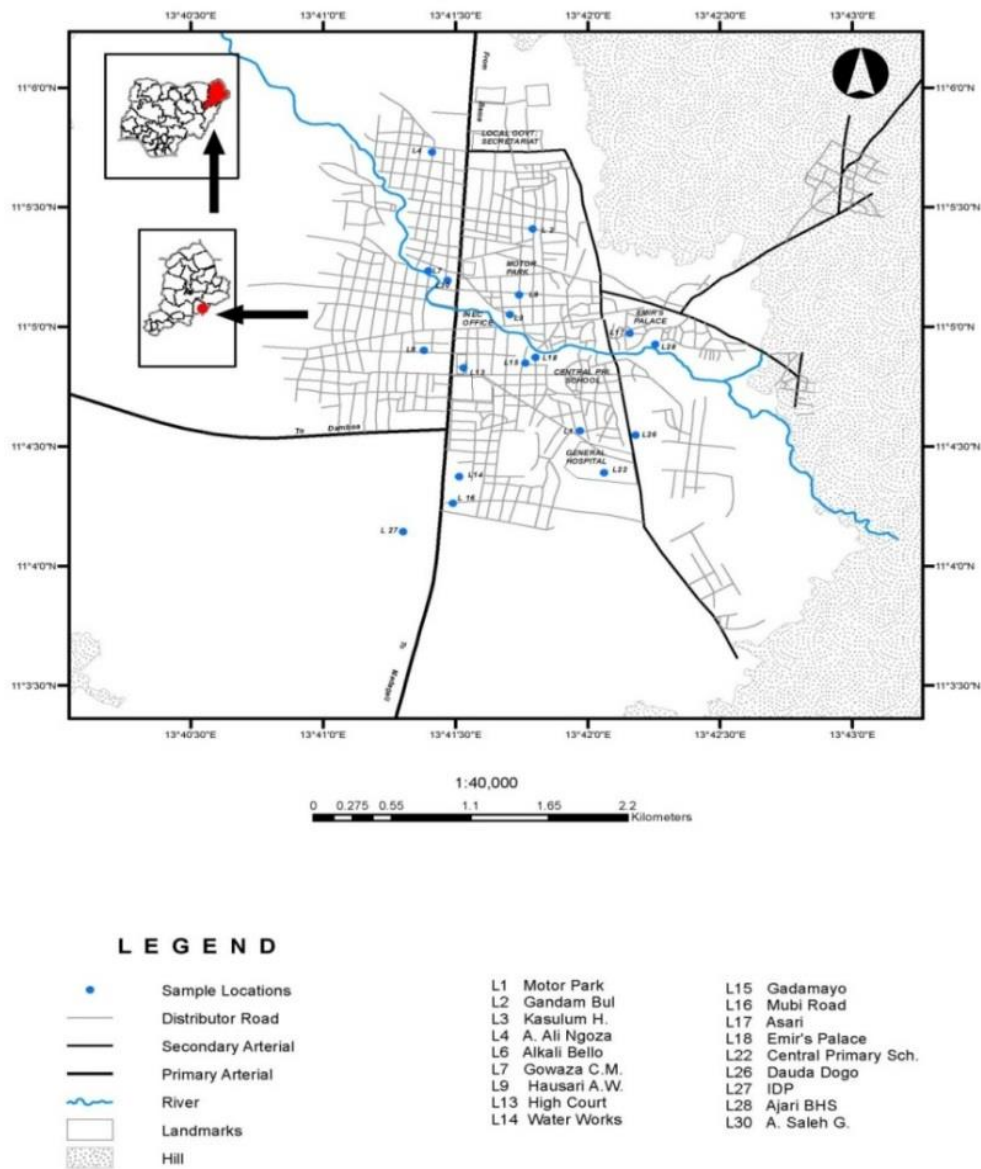


Figure 1: Location map showing sampling points

The Older Granites which are the most widespread rock units in the area occur as basic, intermediate or acid intrusive (Turner, 1964), with varying textures from medium – coarse – grained and sometimes porphyritic. They occur as prominent batholithic masses in many parts of the basement complex. Minor rocks in the area include dolerites, pegmatities, rhyolites and mylonites (Mc Curry, 1976). Dolerites and pegmatite rocks occur as intrusive dykes and vein bodies in both the Undifferentiated Basement Complex and the Older Granite (Carter *et al.*, 1963; and Mc Curry, 1976).

MATERIALS AND METHODS

Eighteen water samples were collected from hand dug wells spread randomly in Gwoza town. The locations of the well were recorded using Geographical Positioning System (GPS) tool (model: Garmin GPSmap 76CSx), on the spot. The temperature, pH value and TDS were measured using portable digital HANNA conductivity meter (Model H1 98129) on the field during sampling campaign of each well. A 1000 cm³ plastic container was used and filled to brim and close with cap. The bottle was rinsed twice with the sample before collection. The physical parameters of pH, EC and temperature were measured using LAQUAtwin compact water quality meter were measured on the field. While

Hydrogeology

Phreatic water table aquifer conditions are found to exist in the area. The most important hydrologic unit in the area is the weathered part of the basement complex rock and the thickness of the weathered zones may be up to 30 m bgl. These units result mainly from the weathering of the basement rocks, is exposed to the major zone of the ground water occurrence in the area. However, joints and fractures can be seen on the granites of the Mandara mountain range.

the chemical parameters include Na, K, Ca, Cl, HCO₃, NO₃, SO₄, Mg, Fe and Mn were analysed using Flame photometer, spectrophotometric and titration techniques in the department of Geology, University of Maiduguri. These techniques were adopted due to their efficiency and easy to use, hence used by most researchers (Yakubu and Yusuf, 2017).

RESULTS AND DISCUSSION

The results obtained from the analyses were plotted as a scattered point for each element. This plot shows the concentration of each selected element or measured parameter (Y-axis) versus the hand dug well number or sample location on X-axis

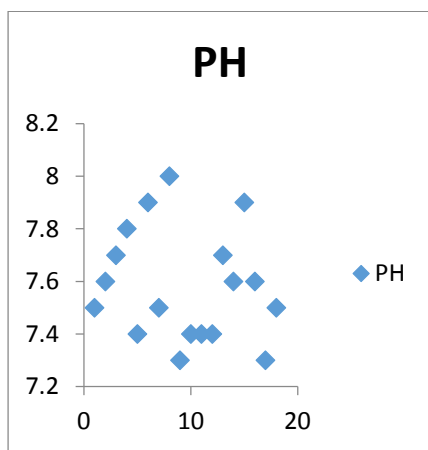


Fig.2: Illustrates the pH concentrations in the groundwater samples analysed

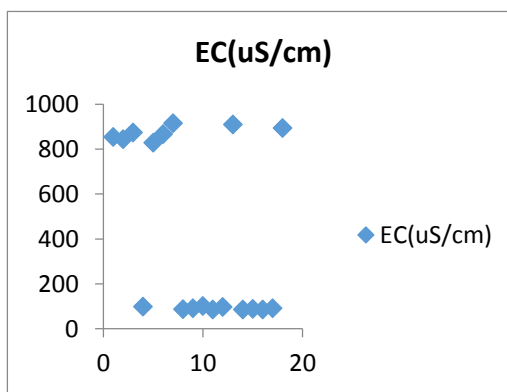


Fig.3: EC concentrations for the groundwater samples analysed

pH is a measure of how acidic/basic water is. It has a scale ranges from 0 to 14. In general, water with a pH < 7 is considered acidic and with a pH > 7 is considered basic. The normal range for pH in surface water systems is 6.5 to 8.5 and for groundwater systems 6 to 8.5. Alkalinity is a measure of the capacity of the

water to resists a change in pH that would tend to make the water more acidic. The pH values for the groundwater in the area ranged from 7.30 to 8.0 with an average of 7.58 (Fig.2). According to WHO (2011), the normal range for pH in surface water systems is 6.5 to 8.5 and for groundwater systems 6 to 8.5. The pH concentration of all the samples analyzed fall

within the WHO (2011) permissible limits for drinking water and is good for domestic use.

Electrical Conductivity (EC) is a measure of the dissolved ionic component in water and hence electrical characteristic. It is an indirect measurement of salinity, and is temperature dependent and good indicator of the total salinity in water sample. A plot of conductivity

values of the ground water samples are presented in figure 3. The results indicates that EC concentrations range between 85.40 $\mu\text{S}/\text{cm}$ with an average of 315 $\mu\text{S}/\text{cm}$ with an average of 314 $\mu\text{S}/\text{cm}$ and falls within the WHO (2011) permissible limits of 1500 $\mu\text{S}/\text{cm}$ for drinking water and other domestic uses.

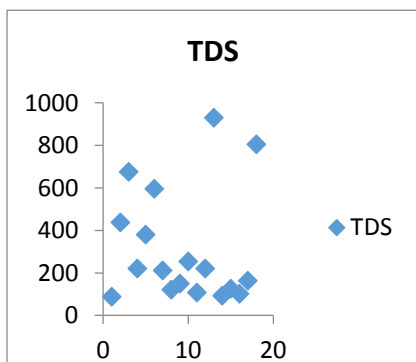


Fig.4: TDS concentrations for the groundwater samples analysed in the study area.

Total dissolved solids (TDS) describe all solids, commonly mineral salts that are dissolved in water. Water sample containing TDS value less than 1000 ppm is rated as fresh water. The maximum permissible limit (WHO, 2011) of TDS for drinking water is 1500 ppm. From the groundwater samples analyzed, the TDS concentration ranges from 88 to 930 mg/L with an average of 315 mg/L, hence falls within the permissible limit for drinking water (Fig.4).

Sodium is the most abundant mineral in the earth's crust. About 60% of sodium is from igneous rock in the earth's crust consisting of feldspar minerals. Other sources of sodium

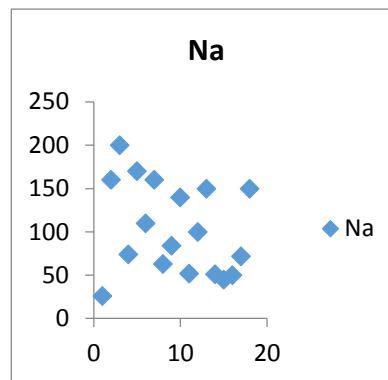


Fig.5: Sodium concentration in the groundwater samples in the area

include; Salt water intrusion into wells in coastal areas, infiltration of surface water contaminated by road salt, irrigation and precipitation leaching through soils high in sodium, groundwater pollution by sewage effluent and infiltration of leachate from landfills or industrial sites.

Sodium is a principal chemical in bodily fluids, and it is not considered harmful at normal levels of intake from combined food and drinking water sources. However, increased intake of sodium in drinking water may be problematic for people with hypertension, heart disease or kidney problems that require them to follow a low sodium diet. The plots of concentrations of sodium for the samples analyzed in the study area are presented in figure 5 and falls within WHO (2011) set standard for drinking water.

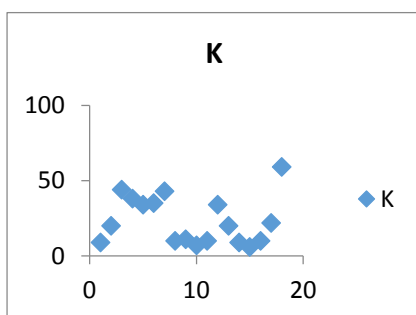


Fig.6: Potassium concentration in groundwater samples in the area

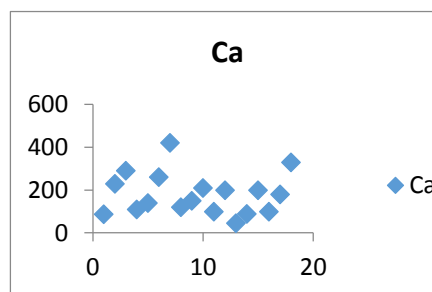


Fig.7: Ca concentration in the groundwater samples analysed

The sources of potassium in surface and groundwater are attributed to minerals of silicate rocks (orthoclase and microcline), the micas and the feldspathoids. In dilute natural waters, potassium concentration is less than 10 mg/L. Potassium generally appears to be within 10 mg/L in water (Todd,1980).

The potassium content in groundwater in the area ranges between 6 to 59 mg/L (Fig. 6). The concentration in 10 samples analysed exceeded the desirable limit of 10 mg/L (WHO 2011). The samples in L1, L15, L22 and L26 having values of 9 mg/L, 7 mg/L, 9 mg/L and 6 mg/L respectively are within required level. Feldspar minerals and potassium bearing micas of the

study area are natural sources of potassium in the groundwater.

Calcium ion in drinking water is essential for teeth and bones development. The occurrence of Calcium in the groundwater of area is between 45 to 420 mg/L, about six samples have concentration of Calcium exceeding the permissible limit of WHO (2011) which is 200 mg/L. The samples in L2, L3, L7, L9, L15 and L30 with elevated values of 230 mg/L, 290 mg/L, 260 mg/L, 420 mg/L, 210 mg/L and 330 mg/L respectively. The dissolution of minerals like, hornblende, calcite, fluorite and feldspars are the sources of this calcium in the groundwater of the area

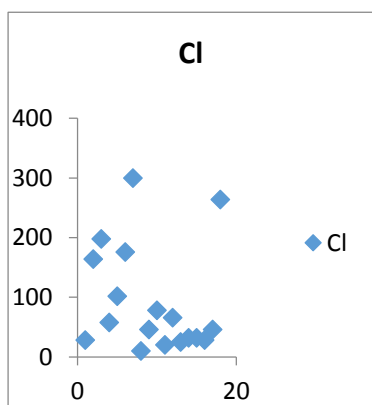


Fig.8: Cl concentration in the groundwater samples analysed in the area.

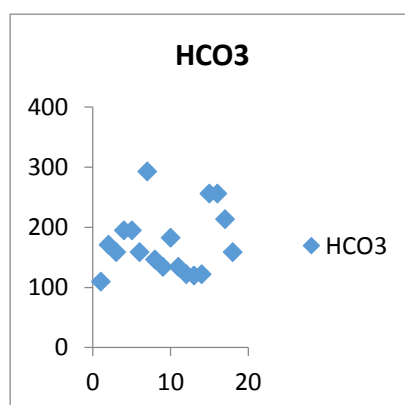


Fig.9: HCO₃ concentration in the groundwater samples analysed.

Chloride in groundwater originates from both natural and anthropogenic sources. The Chloride concentrations in two locations were much higher than the permissible limits. High chloride content indicates heavy pollution. It can be due to the uses of inorganic fertilizer, landfills leachates, septic tank effluent and industrial and irrigation drainage. The high concentration of chloride gives an undesirable taste to water and beverage. Taste thresholds for the chloride anion depends on the associated cation and are

in the range of 200 – 300 mg/L for sodium, potassium, calcium and chlorides. The Chloride concentrations varies from 10 to 300 mg/L (Fig. 8) and the maximum tolerable limit of chloride in drinking water is 250 mg/L for WHO (2011), beyond which it imparts salty taste. The Cl concentrations in L19 and L30 with 300 and 264 mg/L respectively fall above the permissible limit while the remaining 16 samples are within the limit and safe for drinking purposes.

Bicarbonates and carbonates attribute the alkalinity of water and the maximum desirable

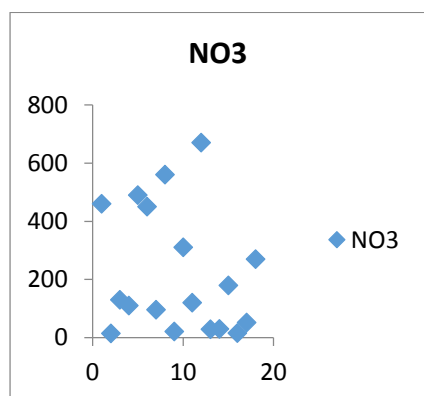


Fig.10: NO₃ Concentration in the groundwater samples analysed

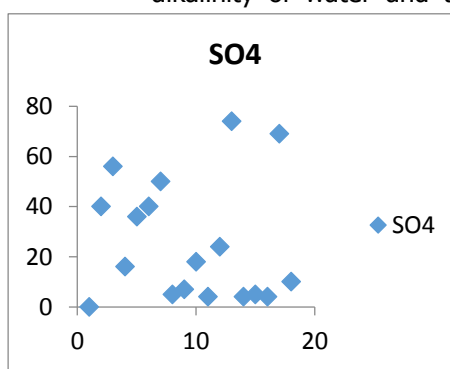


Fig.11: SO₄ Concentration in the groundwater sample analysed

limit of alkalinity is 600 mg/L. The concentration of bicarbonate varies from 109 to 292 mg/L and all fall within the WHO (2011) permissible limit for drinking water (Fig. 9).

Nitrate is found naturally in the environment and is an important plant nutrient. Nitrate can reach both surface and groundwater as a consequence of agricultural activity (including excess application of inorganic nitrogenous fertilizer and manures), from wastewater disposal and from oxidation of nitrogenous waste products in human and animal excreta, including septic tanks. Some groundwater may also have nitrate contamination as a consequence of leaching from natural vegetation. In the case of bottled-for infants, drinking-water can be the major external source of exposure to nitrate and nitrite.

Twelve samples (65%) have NO₃ concentration much more above the WHO (2011) standard

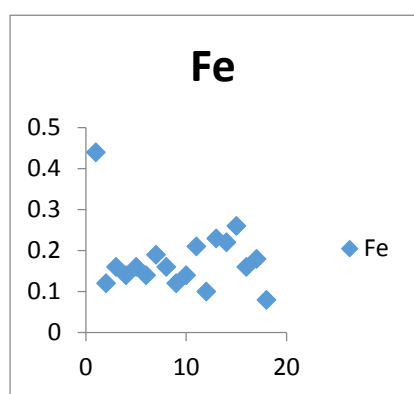


Fig.12: Fe concentration in the area

Iron is one of the most abundant metals in earth's crust. It is found in natural fresh water at levels ranging from 0.5 to 50 mg/L. Iron may also be present in drinking water as a result of the use of iron coagulants or the corrosion of steel and cast iron pipes during water distribution. Iron is an essential element in human nutrition, particularly for iron depends on age, sex, physiological status and iron bioavailability range from about 10 to 50 mg/day. Drinking water gives value of about 2 mg/L, which does not present a hazard to health. Figure 12 shows the plots of the concentration distribution of Fe in the study area.

Manganese is an essential element for human and animals. Although there have been

permissible limit for drinking water (50 mg/L) as seen in figure 10. This water is therefore not suitable for drinking although it can be used for irrigation purposes.

The presence of sulphate in drinking water can cause noticeable taste, and very high levels might cause a laxative effect in unaccustomed consumers. Taste impairment varies with the nature of the associated cation; taste threshold have been found to range up to 250 mg/L. However, the concentration of sulphate for the groundwater samples analysed in the study area fall within the WHO (2011) permissible limit for drinking water (Fig. 11).

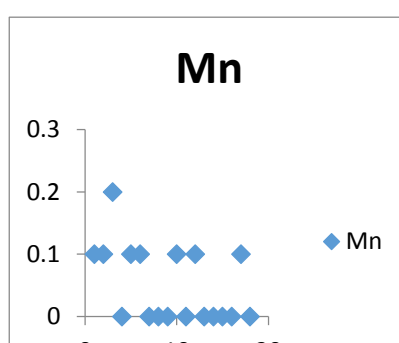


Fig.13: Indicates the Mn concentration in the area

epidemiological studies the report adverse neurological effects following extended exposure to very high levels in drinking-water, there are a number of significant potential confounding factors in these studies, and a number of other studies have failed to observe effects following exposure through drinking water. At levels exceeding 0.1 mg/L, manganese in water and laundry. Only L3 has a value of 0.2 mg/L which is above the permissible level (Fig.13).

The presence of manganese in drinking-water, like that of iron, may lead to the accumulation of deposits in the distribution system. Concentrations below 0.1 mg/L are usually acceptable to consumers. Even at a concentration of 0.2 mg/L, manganese will often from a costing on pipes, which may slough off as black precipitate.

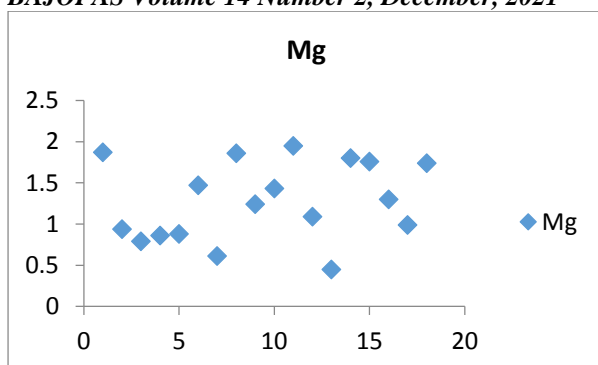


Fig.14: Shows the concentration of Magnesium in the study area.

Magnesium ion is responsible for bone density. The desirable limit of magnesium in water for domestic purpose is 100 mg/L and in ranged from 0.45 to 1.95 mg/L in the area (Fig.14). High concentration of magnesium leads to scaling of water conducting pipes. The hornblende and clay minerals in the study area contribute to the magnesium concentration in the groundwater.

Increased intake of magnesium salts may cause a temporary adaptable change in bowel habits (diarrhea), but seldom causes hypermagnesaemia in persons with normal kidney function. Drinking-water in which both magnesium and sulphate are present at high

concentrations (above approximately 250 mg/L each) can have a laxative effect, although data suggest that consumers adapt to these levels as exposure continue. Laxative effects have also been associated with excess intake of magnesium taken in the form of supplements, but not with magnesium in diet.

CONCLUSION AND RECOMMENDATION

Most of the parameters analysed are within the WHO, 2011 standard of drinking water. Chloride and Nitrate in some locations are found to have elevated concentration. Total coliform test is recommended to ascertain its quality.

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