EVALUATION OF BOREHOLE WATER QUALITY USED BY SELECTED TERTIARY INSTITUTIONS IN JIMETA - YOLA METROPOLIS, ADAMAWA STATE, NIGERIA

Maspalma, G. A[1*], Adamu, Z[1], Ngoshe, A.M[2] and Ogbusua, K. N.[3]

[1]Department of Science Laboratory Technology, Chemistry Unit, Adamawa State Polytechnic, Yola,
[2]Department of Chemistry, Federal College of Education Yola Adamawa State
[3]Department of Chemistry, Abia State College of Education (Technical), Arochukwu, Abia State
* Corresponding author: agoddypalma@yahoo.com; GSM: +2347035410631

ABSTRACT

Adequate provisions of water supply both qualitative and quantitative, in tertiary institutions has a number of positive effects and contribute to reduction of disease among students, staff and their families. A total of twenty-four water samples were collected from six boreholes and were analyzed for physical parameters in situ, while those for chemical parameters were analyzed in the laboratory using standard method. The results obtained were compared with standard guideline values for drinking water quality provided by World Health Organization (WHO) and that of the Nigerian Standard for Drinking Water Quality (NSDWQ). The study revealed that water samples from borehole BH2, BH4 and BH6 are harder, while those from other boreholes are good. The concentration of the major cations (calcium and magnesium), trace metals (Iron and Zinc) and anions (sulphate and nitrate) were within the respective permissible limit recommended by WHO and NSDWQ. The concentration of Lead falls within the acceptable limit, though it can be harmful to the human health, even at low concentration. The values of the electrical conductivity, total dissolved solid, pH and turbidity of most of the samples fall within the maximum allowable limits. Thus, the water qualities of the boreholes surveyed were good. It is recommended that provision of safe water supply through boreholes, be encouraged in tertiary institutions, since the quality falls within the recommended acceptable limits.

Key words: Borehole, physical, chemical, water quality, tertiary institution.

INTRODUCTION

About 80% of all communicable diseases affecting human beings are either water borne or water related according to the World Health Organization (WHO, 2006). Diseases such as typhoid, dysentery, cholera, meningitis and diarrhea are signatures of drinking unsafe water. The quality of water is assessed by its physical, chemical and bacteriological characteristics and is usually compared with the World Health Organization (WHO, 2006) and Nigerian Standard for Drinking Water Quality (NSDWQ, 2007) among others.

Water is essential for life and is the major constituent of almost all forms of life, without water, life would probably never have developed on our planet (Edema, 2001). In most cities, town and villages in Nigeria, valuable man-hour is spent on seeking and fetching water, often of doubt quality from distant sources (Efe *et al*., 2005). In Yola- Jimeta metropolis, over 40% of households depend on water from boreholes as their main source of domestic water supply (National Population Commission, 2006).

The high population density, poor sanitation habits and lack of enforcement of environmental sanitation, laws have contributed immensely to the pollution of water sources. Pollutants in borehole water can be from various sources, mainly municipal (i.e. leakages from liquid waste and solid waste from land fill and also leakages from pipes), industrial (i.e. liquid waste tanks and pipe line leakages, oil field and brines) and agricultural sources (i.e. irrigation return flow which are sometime saline).The quality of ground water resource depends on the management of human waste as well as the natural physical and chemical characteristic of the catchment area (Efe *et al*., 2005; Saha & Buba, 2004). Also depending on the geology of an area, underground water is typically rich in dissolved salts especially carbonates and sulphates of calcium and magnesium. Other ions may also be present including chlorides and bicarbonates.

In a society like Yola-Jimeta metropolis where borehole is the main source of domestic water supply, contamination will not only expose people to and increase occurrences of life-threatening water borne diseases but also negate any development goals. Many tertiary institutions serve communities that have high prevalence of disease related to adequate water supply and other underlying health problems are common. Students are likely to be affected in different ways and thus may contribute to unequal learning opportunities. It is against this background that the evaluation of borehole water used by selected tertiary institution within Yola-Jimeta metropolis was carried out, with a view to highlighting the sources of contaminants and possible effect on the students, staffs and their families.

MATERIALS AND METHODS

Precaution: To ensure reliability of the result, samples were carefully handled to avoid contamination. All glassware used was soaked in 1M nitric acid for 48hours and rinsed with pure water. The reagents (nitric acid) were of analytical grade.

Study Area: The study area is a metropolis made up of the twin cities of Yola and Jimeta in the North Eastern Adamawa state of Nigeria. The Yola-Jimeta metropolis is located between 9° 11^{1} N and 9° 19^{I} N latitude and 12° 12^{I} E and 12° 30^{I} E longitude covering an area of about 1,213 km^2 (Adebayo & Umar, 1999) and has a population of 344,154 (National Population Commission, 2006). Closely related to the population is varied land uses which are associated with the urban status of the area and the various urban land uses generate a high demand for water resources. The water supply situation in the area is mainly characterized by scarcity especially in the dry season; most of the households do not have access to pipe borne water as such they rely on boreholes, hand dug wells, and water vendors for their daily water supply. The study area has a typical dry tropical climate, with marked rainy and dry seasons. The drainage system in the metropolis is mainly dominated by the river Benue and other minor streams and ponds. The area is generally flat to gentle undulating with an elevation ranged from 160 to 190 meters above sea level (Adebayo & Umar, 1999).

Sample collection: The boreholes were randomly selected based on where they were found in the selected tertiary institutions, i.e. (Adamawa State Polytechnic Yola, Federal College of Education Yola, Modibbo Adama University of Technology Yola, Legal Studies Yola, School of Nursing Yola and Federal Polytechnic Yola Campus). A total of Twenty-four water samples were

collected from the randomly selected boreholes, four from each of the six tertiary institutions in Jimeta and Yola metropolis. The samples were collected using a 1.5liter plastic container and chemical analysis was conducted using standard laboratory methods suggested by APHA (American Public Health Association, 1995). All the borehole water samples were collected after the water from the borehole has been pumped for at least 10 min (Ketata et al., 2011).

Analysis of Samples: The portable pH, EC, TDS and Temp meter HI 9811-5 model from Hanna instruments USA, was used in situ for measurement of some physico-chemical parameters (EC, pH, TDS and Temperature), because these parameters vary with environmental condition, such as temperature.

A HACH 2100P turbiditimeter was used for measuring the turbidity of the samples. The atomic absorption spectrophotometer was used in the determination of the concentrations of Iron (Fe), Zinc (Zn) and Lead (Pb), while volumetric method was used in the analyses of total hardness ($CaCO^3$), calcium (Ca^{2+}) and Mg^{2+} was calculated from concentrations of total hardness and calcium according to Sawyer et al. (2003) as:

Total Hardness (mg/L) = $(Ca^{2+} + Mg^{2+}) \times 50$ . . . . (1)

where Ca^{2+} and Mg^{2+} concentrations are expressed in mg/L.

RESULTS AND DISCUSSIONS

The result of the water quality analysis carried out on the water samples from borehole of different tertiary institution are presented in Table 1. The World Health Organization (WHO) standard for drinking water was used as the baseline to compare the water quality from the different sources.

Table 1: Result of physicochemical concentration of water samples from different tertiary institution

Parameters	EC.	pH.	TDS.	Temp.	$CaCO_3$.	TBT,	SO_4^{-3}	NO^{-3}	Ca.	Mg.	Fe.	Zn.	Pb
Samples	µS/cm		mg/L	°c	mg/L	mg/L.	mg/L	mg/L	mg/L	mg/L.	mg/L	mg/L.	mg/L.
BH1	0.27	6.3	0.31	29	66.11	2 .00	4.60	1.02	0.046	1.16	0.003	0.009	0.004
BH2	0.02	7.34	0.30	29	71.03	3.44	4.98	0.09	0.032	3.21	0.001	0.005	0.004
BH3	0.06	7.1	0.01	30	58.92	2.49	3.79	1.03	0.071	2.00	0.002	0.005	0.004
BH4	0.14	8.21	0.08	32	83.20	4.99	4.66	2.42	0.066	2.88	0.002	0.021	0.001
BH5	0.01	8.1	0.17	30	61.90	4.64	3.99	2.10	0.074	1.96	0.002	0.026	0.003
BH6	1.66	8.22	0.13	30	81.46	3.66	3.93	2.34	0.064	1.63	0.003	0.030	0.001
Minimum	0.01	6.3	0.01	29	58.92	2.00	3.79	0.09	0.032	1.16	0.001	0.021	0.001
Maximum	1.66	8.22	0.31	32	83.20	4.99	4.98	2.34	0.074	3.21	0.003	0.030	0.004
Mean	0.36	7.55	0.17	30	70.44	3.54	4.33	1.50	0.058	2.14	0.002	0.016	0.003
WHO (2006):	100	6.5-8.5	250	-	150	10.0	50.0	50.0	200	50.00	0.3	3.0	0.01
NSDWQ (2007):	100	6.5-8.5	500	-	150	5.0	100	50.0	-	0.20	0.3	3.0	0.01

Key: BHI = State Polytechnic, BH2= Federal College of Education, BH3= Mautech, BH4 = Legal Studies, BH5 = School of Nursing, BH6= Federal Polytechnic Yola Campus.

pH in water is an indication of the hydrogen ions (H^+) and negative hydroxide ions (OH^-) in water, to indicate whether the water is acidic or alkaline (World Health Organization, 2006). In pure water, the concentration of positive hydrogen ions is in equilibrium with the concentration of negative hydroxide ions, and the pH measures exactly 7. The WHO set a pH guideline value of between 6.5 and 8.5 as generally considered satisfactory for drinking water. The pH of borehole water of our study area ranged between 6.3 and 8.22. Borehole water with pH below 6.5 is generally considered acidic. This relates to borehole water from BH1 with pH of 6.3, which is mildly acidic. pH is generally considered to have no direct impact on humans. Acidity increases the capacity of the water to attack geological materials and leach toxic trace metals into the water making it potentially harmful for human consumption. On the average all the boreholes fall within the WHO acceptable limits of 6.5 to 8.5.

Temperature is important because the rate of chemical reaction increases at higher temperature which in turn affects biological activities and growth of aquatic organisms. The values for Temperature of each sample are shown in Table 2. The temperature of the samples from the various sources varied from 29.0^{o}C to 32.0^{o}C with an average value of 30.0^{o}C. Temperatures of samples from other borehole were slightly higher than that from other boreholes. There is no guideline value recommended by WHO with regards to temperature of drinking water. High temperature enhances the solubility and mobility of metals (Amadi, et al., 2015)

Electrical conductivity (EC) estimates the total amount of dissolved ions or the total dissolved salts in the water. The electrical conductivity of borehole water samples analyzed ranges from 0.01 µS/cm to 1.66 µS/cm with an average value of 0.36 µS/cm. The EC values of the different sources falls within the maximum permissible limit of 100.00 µS/cm recommended by World Health Organization (2006). Turbidity of water refers to how clear the water is and is caused by the presence of particulate matter such as clay, silt, plankton and colloidal particles. The major effect of turbidity is aesthetic and high levels of turbidity for a short period of time may not be significant than a lower persistent level. However, high turbidity in drinking water which correlates positively with TDS can cause color/odor problem (Warizi, et al., 2012). The WHO acceptable limit for turbidity is 10NTU and all samples investigated fall within the permissible limit.

Total dissolved solid is defined as an inorganic salt, organic matter and other dissolved material in water (World Health Organization, 2011). High TDS valves may result in a salty taste to the water, measuring total dissolved solids is a way to estimate the suitability of water for drinking. During the rainy season soil, rocks, road, construction sites, dump runoff pick up a lot of dissolved and particulate material in water. Ions such as potassium, sodium, chloride, carbonates, sulphate, calcium and magnesium all contribute to the dissolved solids in water. The total dissolved solids values for all the samples were within the safe limits

The concentration of nitrate in the six tertiary institution ranges between 0.09mg/liter to 2.34 mg/liter and is within the permissible limit of 50 mg/liter, suggested by WHO. The main source of nitrate contaminant in water is through run-off from farmlands (Chiroma et al., 2007). Nitrate is a major ingredient of farm fertilizer and is necessary for crop production. Nitrate can also get into shallow

groundwater from leaking of wastewater (where latrines and septic tanks are poorly sited) or other organic wastes (from animal's livestock, fish and birds) into groundwater. The concentration of sulphate in the six tertiary institutions study area range between 3.79 and 4.98mg/liter with the average value of 4.33 mg/liter. According to WHO (2006), taste thresholds for sulphate in water have been found to range from 250 mg/liter for sodium sulphate to 1000 mg/liter for calcium sulphate. It is generally considered that taste impairment is minimal at levels below 250 mg/liter, hence the 250 mg/liter used for this study. In any case, the sulphate concentrations in all the wards are within the WHO guidelines.

Approximately 99 percent of the body's calcium stores are found in bones and teeth with small amounts in the tissue and body fluids necessary for muscle contraction, nerves transmission and glandular secretion and its high concentration in water does not constitute any health hazard. The concentration of calcium ranged from 0.032 mg/L to 0.074 mg/L with average value of 0.050 mg/L. The concentrations of calcium in all the samples analyzed were below the permissible limit of 200.00 mg/L postulated by World Health Organization, (2011). Magnesium is vital to the activity of many enzymes. It is required for the production of energy, protein synthesis, muscle and nerve functions. It plays a vital role in the proper use of calcium (Maspalma, et al., 2016). Magnesium concentration varied from 1.16 mg/L to 3.21 mg/L with an average value of 2.14 mg/L. The presence of calcium and magnesium ions in water is responsible for hardness of water. Magnesium is required in higher quantities during the rapid growth phase in children. Its level in the groundwater when low is believed to cause magnesium deficiency in children from lower socio-economic groups who also suffer from nutritional insufficiency.

According to the WHO, iron concentration below 0.3 mg/liter may develop turbidity and colour. Although, low iron concentration is not considered as serious health concern, the EU (European Union) even recommends a 0.2 mg/liter (The Council of the European Union, 1998). The concentration of iron ranged from 0.001 mg/L to 0.003mg/L with a mean value of 0.002 mg/L as against the maximum permissible limit of 0.10 mg/L (WHO, 2006). The deficiency when prolonged will be fatal. When iron is increased in body acutely, nausea, vomiting, diarrhea occurs along with hepatic damage. While chronic or prolonged accumulation of iron in body occurs, there is a hepatic failure, diabetes, arthritis, cardiomyopathy, peripheral neuropathy and hyperpigmentation

The metal zinc is an omnipotent metal that has amphoteric nature. Hence, it is ionized either in acidic or alkaline forms. Content of zinc is 2-3 ng the average body content of zinc is 2-3 g in an average adult (Satyanarayana & Chakrapani, 2008). Zinc has been identified as a cofactor in at least forty different systems covering every major physiological function dependent upon enzymes. Without adequate zinc for examples, carbon dioxide exchanged in cell could not take place at a fast-enough rate to sustain life. Zinc concentration range between 0.021 mg/liter and 0.030 mg/liter with a mean of 0.016 mg/liter. All the boreholes passed WHO guideline at 3 mg/liter for Zinc. Lead is a toxic substance that poses a variety of danger for humans, it can enter drinking water when service pipes that contain lead corrode, especially where the water has high acidity or low mineral content that corrodes pipes and fixture. High level of lead in the body can cause lasting

problem with growth and development, these can affect behavior, hearing and learning and can slow child's growth and it can damage the brain, kidney, nervous system and stomach of both children and adults. The concentrations of lead were found to exceed the maximum permissible limit of 0.01 mg/L (World Health Organization, 2006). The value ranged between 0.001 mg/L and 0.004 mg/L with an average of 0.003 mg/L. All the boreholes water analyzed were lower than the WHO (2006) stipulated limit of 0.010 mg/L for drinking water. EPA has set the maximum contaminant level goal for lead in drinking water at zero because lead is a toxic metal that can be harmful to human health even at low exposure levels it is persistent and can bioaccumulate in the body over time (World Health Organization, 2011).

CONCLUSION AND RECOMMENDATIONS

Water borne disease, sanitation and hygiene are of a great concern to developing countries, it is estimated that 88 percent of diarrheal disease is caused by unsafe water supply. This study revealed that water from some borehole has some trace of hardiness while the other boreholes are of good quality. However, the hardness does not constitute a major problem. The concentration of the major cations (calcium and magnesium,) trace metals (Iron and Zinc), anions (sulphate and nitrate) and Heavy metal (Lead) were within the respective permissible limit recommended by WHO (2006, 2007, 2011) and NSDWQ (2007). The values of the electrical conductivity, total dissolved solid, pH and turbidity also falls within the maximum allowable limits, with an exception of sample BH1 with pH of 6.3 and all samples BH1 to BH6 for Lead are lower than the permissible limit of 0.01mg/L, though it can be harmful to the human health even at low concentration. The slightly acidic nature of water in the boreholes encourages the dissolution of the iron into the groundwater system.

Although the water quality of the boreholes surveyed were good. It is recommended that continuous water quality monitoring and steady sanitation around the boreholes should be encouraged. Also, provision of safe water supply through boreholes, be encouraged in tertiary institutions, since the quality falls within the recommended acceptable limits.

REFERENCES

Adebayo A.A. and Umar A.S., (1999). *Hydrology and Water Resources*. A.A. Adebayo, A.L. Tukur, eds. Adamawa state in maps. Paraclete Publishers, Yola, Nigeria, 17-19.

Amadi A. N., Tukur Aminu., Okunlola I. A., Olasehinde, P. I. and Jimoh M. O., (2015). Lithological influence on the Hydro Geochemical Characteristics of Groundwater in Zango, North-west Nigeria. *Natural Resources and Conservation*, 3 (1), 11 – 18.

American Public Health Association (1995). *Standard Methods for the Examination of Water and Wastewater*, 19th edition. American Public Health Association, Washington, DC.

Chiroma H.D., Ayinla G.T., Orish O.E., Emmanuel O.O., Jigam A.A., Makun H.A., Sani G.M., Johnson A.O. and Humphrey P., (2007). Seasonal Nitrate Content of Stream Water, Soil and Some Foodstuffs Samples in Abuja Municipal Area of Federal Capital Territory, *Nigeria Journal of Health Science. 53(4), 359-364*

Edema M. O, Omemu A.M and Fapetu O.M, (2001). Microbiological and physicochemical analysis of different sources of drinking water, *Nigeria journal of Microbiology,* 15*, 57 - 61.*

Efe, S.I, Ogban, F.E, Horsfall, M. J. and Akporhonor, E.E (2005). Season Variation of Physicochemical Characteristic in Water Resources Quality in western Nigeria Delta Region, *Nigeria Journal of Applied Science and Environmental Management,* 9(1),191 -195.

Ketata M., Gueddari M. and Bouhlila R, (2011). Suitability assessment of shallow and deep groundwater for drinking and irrigation use in the El Khairat aquifer (Enfidha, Tunisian Sahel) Environmental. Earth Science.

Maspalma G. A, Adamu, Z and Ndonya A. E, (2016). Variation of concentrations of potassium (k), calcium (Ca), magnesium (Mg) and sodium (Na) in banana (musa sapientum) fruit from sprouting to rotten stages. *International Journal of Advancement in Biological Science,* 6 (1), 65 -69.

National Population Commission (2006). Population and Housing Census of the Federal Republic of Nigeria 2006 Census: Priority Tables. National Population Commission, Abuja, Nigeria.

National Primary Drinking Water Regulation, (2006). Ground water and drinking water, Washington DC US Environment protection Agency (EPA).

Nigerian Standard for Drinking Water Quality (2007). NIS, 554, 1-14.

Saba, A.M and Buba A.H, (2004). Physicochemical and bacteriological characteristics of river Landzu, Bida Nigeria. *Proceeding of the 8th National Engineering conferences, Kaduna Polytechnic, Kaduna.*

Satyanarayana U. and Chakrapani U, (2008). *Essentials of Biochemistry*. 2nd ed. Kolkata: Arunabha Sen Book and Allied (P) Ltd., 210-27.

Sawyer G.N., McMcartly D.L. and Parkin G.F., (2003). *Chemistry for environmental engineering and science*, 5th edition. McGraw Hill, New York.

Waziri, M, Akinniyi J, A. and Ogbodo, O.U, (2012). Assessment of the physicochemical characteristics of rain and runoff water in University of Maiduguri-Nigeria staff quarter, *American journal of scientific and industrial research. 3 (2), 99 – 102.*

World Health Organization, (2006). *Guidelines for Drinking-water Quality*. World Health Organization, Geneva, Switzerland.

World Health Organization, (2007). *pH in drinking-water. Background document for preparation of WHO Guidelines for drinking-water quality*. World Health Organization, Geneva.

World Health Organization (WHO), (2011). Guidelines for Drinking-water Quality. 4th Edition WHO press Geneva, Switzerland, 564.