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ASSESSMENT OF THE PHYSICO-CHEMICAL PROPERTIES OF BOREHOLE WATER IN GWAGWALADA AREA COUNCIL ABUJA, NIGERIA

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ABSTRACT

The assumption that borehole water is safe for drinking purpose was verified by empirical study of the physico-chemical properties of borehole water in Gwagwalada Area Council Abuja, Nigeria. The physico-chemical properties of borehole water were anaysed and compared with regulatory standards for drinking purpose. Fifteen samples were collected from five purposely selected wards (Dobi, Ibwa, Tungan-Maje, Zuba and Ikwa) in the study area. The selections of the wards were based on heavy reliance on borehole water for drinking. Three borehole water samples were spatially collected from each of the five selected wards. The water samples were stored in 75cl plastic bottles pre-cleaned with distilled water and rinsed with the sample water. Each sample was labeled with the name of the ward and transported to the laboratory for analysis. Data were analyzed using range and mean. Result showed that water sample were slight acidic (6.83) to slight alkalinity (7.86) EC was low and ranged from 132-184µS/cm^3, TDS 1.4-3.1Mg/l, turbidity 0.36-71NTU, Total hardness 6.12-19.72Mg/l, Chloride (Cl-)1.03-16.86Mg/l, Fe 0.08-0.72Mg/l, Zn 0.021-0.051Mg/l, Cr 0.016-0.086Mg/l, Cd 0.001-0.009Mg/l and Mn from 0.002-0.009Mg/l. Some sample fell short of regulatory standards in terms of EC and FE. However, most water samples are safe for drinking purpose. Treatment of sources that fell short of standard before drinking was recommended.

KEYWORD: Water, Borehole, Water quality, Drinking water, Gwagwalada

INTRODUCTION

Borehole drilling by households for domestic water supply is a common practice in the Federal Capital Territory Abuja, Nigeria. This has called for concern on the potential effects on the landscape (Adekunle, 2018) with negligible concern on the safety of borehole water for consumption. The common assumption is that underground water is not polluted and thus, safe for drinking. However, there are factors that may affect borehole water quality. According to Banoeng-Yakubo *et al*., (2009) the quality of borehole water depends on locational and anthropogenic factors. Location, climate, soil and rock types through which the water moves can affect the quality (Boadi *et al*., 2020).Human activities such as disposal of chemicals and microbiological material on landfill sites, waste burning or even directly injecting of waste into the groundwater can alter the water natural composition and quality (Calow, *et al*., 2010; Grant and Dietrich, 2017; Pitt, *et al*., 2019). The use of artisans and consequential improper drilling of boreholes may also cause groundwater contamination (Boadi *et al*., 2020).

The inability of the Government to supply tap water to residents of some parts Gwagwalada Area Council is still a challenge. The inadequate access to drinking water has activated the sinking of boreholes in most homes within new settlements and some old settlements due to the unreliability of pipe-borne water sources. The Federal Capital Territory Abuja, Nigeria has two major water treatment dams, namely, the Gurara and Usuma Dams, which are supposed to serve the entire Area. However, these treated water sources are not enough to reach the fastest-growing city in Africa (United Nations UN, 2019). Thus, individuals sink boreholes and pump the water for household use and in cases sale to water vendors who supply other homes.

Borehole water is rarely tested for safety despite that some conditions capable of polluting ground water has been reported in the city (Magaji 2012; Saadatu, 2013;

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Owoseye, 2019). For examples, Owoseye (2019) observed that the F.C.T currently practiced open waste dumping. However, concern over exposure to drinking water contaminants and the resultant adverse effect on human health has prompted several studies evaluating the quality of drinking water sources (Nkamare *et al*., 2012; Igwemmar *et al*., 2013; Peter-Ikechukwu *et al*., 2015; Sabo *et al*., 2020). Nkamare *et al* (2012) recorded that all physico-chemical parameters in borehole water samples from the Okutukutu, Yenagoa Local Government Area, Bayelsa State were within recommended standards. Residual chlorine at the sample tap was less than recommended amount of 0.2mg/l in 61.9% of the boreholes. All borehole samples tested negative for E. coli. 66.7% of stored borehole samples in household tested positive for E. coli but was negative for all other enterococci bacteria. The study has shown that water from the boreholes in the community is safe for drinking and other uses.

Igwemmar *et al*. (2013) in their study in Gwagwalada, Abuja recorded that pH, temperature, turbidity, alkalinity, nitrate, chloride, iron and total hardness of all the borehole water samples were below the World Health Organization (WHO) limits while phosphate and magnesium gave values well above the WHO limits for all the samples except in one case with a magnesium concentration lower than the WHO limit. Also conductivity result showed some boreholes with values below WHO limit while others gave higher values. Generally, the results exhibited significant variation in the parameters studied on the samples; this could be attributed to the geographical positions and depth of the boreholes.

Peter-Ikechukwu *et al*., ((2015) observed that all the samples from the Federal Housing Estate and Sites and Services Areas of Owerri, Imo State did not meet up with the recommended standard of pH (6.5-8.5). However, there was significant difference ($p<0.5$) among samples. The temperatures were all significantly the same and did not exceed standard limit of 37ºC. The total dissolved solids also did not exceed the limit of 500ppm and the conductivity limit was not exceeded. All the samples did not exceed limits for zinc, copper, lead, magnesium, cadmium and iron which are 3mg/l, 1mg/l, 0.01mg/l, 0.02mg/l, 0.03mg/l and 0.3mg/l respectively except for calcium, where some samples were beyond standard of 0.4mg/l. All the samples were significantly different for each parameter except for lead of which the entire sample were all the same.

Sabo *et al*., (2020) investigated borehole and Well waters located within the industrial areas of Bompai, Sharada (Sabuwar gandu), Chalawa (Tsamawa) and Gyadigyadi, Wailari sewage disposal areas with a view to determine their physicochemical qualities. The wells water samples showed elevated mean value of lead (0.14mg/l), EC (590.9 us/cm), TDS (l l9.l3mg/l), DO (4.67mg/l), BOD (1.25mg/1), Zinc (l.76mg/l), iron (0.6mg/l), Manganese (0.44mg/l) and Chromium (0.57mg/1) when compared to the borehole samples with mean average value of lead(0.01mg/l), EC (483.75), TDS (54.0lmg/l), DO (4.l2mg/l), BOD(l .2mg/l), Zinc (0.91mg/l), Iron (0.l6mg/l), Manganese (0.29mg/l) and Chromium (0.05mg/l). The result shows that some of the borehole and well samples are not within the recommended limit of WHO (2006) and NSDWQ (2007) standard for drinking water. The borehole and well water should therefore be protected and treated before consumption.

Dagim *et al*., (2017) carried out analysis of the physicochemical water quality of borehole and spring water supplied to Robe Town. Authors reported that most of the samples comply with the water quality guidelines of Ethiopian limit, WHO and U.SEPA. The pH of the water samples from borehole groundwater source was found to be slightly acidic and above the maximum permissible limit (MPL). High concentration of Fe and Mn that exceeds the MPL set by WHO was found in the three boreholes. The spring water sources were found to be better for drinking than borehole water sources.

Though, several studies have been carried on quality of borehole water including in Gwagwalada Area Council (Igwemmar *et al*., 2013). The present study is necessary due to the need for constant monitoring of drinking water sources and the study by Igwemmar *et al*., (2013) cannot represents the present condition of borehole water in Gwagwalada Area Council. This study therefore, complements the efforts of previous studies and documented the current status of borehole water in the study area through the following objectives achieved. The physico-chemical properties of borehole water were analyzed and compared to the World Health Organization standard for drinking purpose. This provided answers to the research questions: what are the physico-chemical properties of borehole water in Gwagwalada Area Council? Is borehole water in Gwagwalada Area Council safe for drinking purpose?

MATERIALS AND METHODS

Study Area

Gwagwalada is one of the five Local Government area councils in the Federal Capital Territory, Abuja with an area of 1,043 km² and a population of 157,770 at the 2006 census. Its geographical coordinates are 8º 56‘29 North, 7º 5‘31E. The Area Council has ten political wards (Adeniyi and Abdullateef, 2015). The centrality of the town in relation to other Area Council Headquarters makes it influential and important in various socio-economic activities (Brigid *et al*., 2020; 2021). It is where the University of Abuja, Abuja University Teaching Hospital and School of the Gifted are located. Thus, the residents of Gwagwalada Area Council, Abuja supposedly have access to good quality water for domestic uses.

Methods

Field survey for collection of water samples from the study area was conducted in January, 2021. Fifteen (15) borehole water samples were collected from five (5) purposely selected wards in the study. The selections of the wards for sampling were based on heavy reliance of borehole water for domestic use among wards that currently lack public water supply (Brigid *et al*., 2020). Thus, Dobi, Ibwa, Tungan-Maje, Zuba and Ikwa were selected. Three borehole water samples were spatially collected from each of the five selected wards. The water samples were stored in 75cl plastic bottles pre-cleaned with distilled water and finally rinsed three times with the sample water, before taking the sample for analysis. Each sample was labeled with the name of the ward and transported to the laboratory for analysis. Data were analyzed using range, mean and t- test in Microsoft excel 2010 version.

RESULTS AND DISCUSSION

The results of physio-chemical properties of borehole water in Gwagwalada Area Council are presented in table 1.

Table 1: Physio-Chemical Properties of Borehole Water in Gwagwalada Area Council

Parameter	Dobi	Ibwa	Tungan Maje	Zuba	Paikon-Kore	Ikwa	Mean
pH	7.26	7.86	7.52	6.97	6.83	6.91	7.23
E.C(µs/cm3)	132	142	184	154	140	137	151.50
TDS(Mg/l)	1.4	3.1	1.29	3.0	2.1	1.9	2.13
TSS(Mg/l)	0.03	0.05	0.04	0.07	0.30	0.02	0.09
Turb.(NTU	0.37	0.71	0.36	0.65	0.57	0.67	0.56
Total Hard.(Mg/l)	11.58	19.72	10.46	8.26	6.12	12.13	11.38
K Mg/l	3.11	3.62	3.03	3.06	3.01	4.86	3.45
Na Mg/l	4.54	3.42	3.20	5.00	6.30	3.86	4.39
Cl- Mg/l	1.03	0.83	16.86	6.21	10.22	13.72	8.15
Ca Mg/l	28.03	43.75	22.86	34.25	18.04	21.62	28.09
Mg Mg/l	10.83	10.76	11.62	12.23	11.35	10.07	11.14
Fe Mg/l	0.08	0.09	0.08	0.72	0.65	0.64	0.38
Si Mg/l	0.016	0.04	0.06	0.017	0.05	0.05	0.04
Zn Mg/l	0.029	0.021	0.034	0.023	0.039	0.041	0.03
Cr Mg/l	0.038	0.086	0.041	0.015	0.031	0.036	0.04
Cd Mg/l	0.005	0.009	0.009	0.008	0.001	0.002	0.006
Cu Mg/l	0.001	0.002	0.006	0.00	0.002	0.01	0.02
Mn Mg/l	0.009	0.006	0.004	0.002	0.002	0.005	0.05

Table 1: present the physical and chemical properties of borehole water in the study area as follows:

Hydrogen ions (pH) -The concentration of pH in borehole water in the study area ranged from 6.83-7.86 with mean value of 7.23. The result indicates that water sample were slight acidic (6.83) to slight alkalinity (7.86). The range suggests uniformity in the concentration of pH among samples. Olatunji *et al*., (2011) similarly reported uniformity in pH of Asa River in Ilorin, Nigeria.

Electrical Conductivity (E.C) **-**The E.C. in water samples ranged from 132-184µs/cm^3 with mean value of 151.50µs/cm3. The range indicates wide distribution of electrical conductivity of water samples in dry season. However, a wider range of EC (100 to 730 µS cm^{-1}) has been reported by Getahun *et al*., (2014). However, the closer range of 122-154µ^s/cm^3 is relatively low because water of good quality for domestic use should have EC from 1500 µ^s/cm^{3}and above (WHO, 2010).

Total Dissolved Solids (TDS) **-** The concentration of TDS in water samples ranged from 1.4-3.1Mg/l with mean value of 2.13Mg/l. The range indicates wide distribution of TDS in borehole water in the study area. However, it is more uniform than the range of

41.4-227.2mg/l reported by Okoro *et al*., (2017) on three borehole water sources in Nsukka urban area, Enugu state, Nigeria.

TSS - The total suspended solids in water samples ranged from 0.02-0.07Mg/l with mean value of 0.09Mg/l. The range indicates uniformity in concentration of TSS of water in Borehole in the study. Total suspended solids is vital in determining water quality, according to Shalom *et al* (2011) high concentrations of suspended solids can cause many problems for stream health and aquatic life. High TSS in a water body can often mean higher concentrations of germs, bacteria, nutrients, pesticides, and metals in the water which makes water unsafe for consumption.

Turbidity- Turbidity ranged from 0.36-71NTU with mean value of 0.56NTU. The range indicates wide distribution of turbidity in water in Borehole in the study area. Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates (WHO, 2012). High turbidity in water has both esthetic and health effect. Thus, it is essential to eliminate the turbidity of water in order to effectively disinfect it for drinking purposes.

Total Hardness**-** The concentration of total hardness in water in Borehole in the study ranged from 6.12-19.72Mg/l with mean value of 11.38Mg/l. The range indicates wide distribution of total hardness in water. The concentration of total hardness in the water samples is below the report of APHA (2005) but above the report of Akpan-Idiok *et al* (2012). APHA (2005) recorded a range of 29–94 Mg/l and Akpan-Idiok recorded a range of 6.41-19.20Mg/l.

Mineral Nutrients (K, Na, Cl-, Mg, Ca)- The concentrations of minerals nutrients in Borehole in the study area are relatively low except for chloride, magnesium and calcium. The concentrations were as follows: Potassium (K) ranged from 3.03-4.84Mg/l with mean value of 3.45Mg/l. Sodium (Na) ranged from 3.20-6.30Mg/l with mean value of 4.39Mg/l. Chloride (Cl-) ranged from 1.03-16.86Mg/l with mean value of 8.15Mg/l. Magnesium (Mg) ranged from10.07-12.23Mg/l with mean value of 11.14Mg/l. Calcium (Ca) ranged from 18.04-43.75Mg/l with mean value of 28.09Mg/l. The mean concentrations of mineral nutrients {potassium (K), sodium (Na), chloride (Cl-), magnesium (Mg) and calcium (Ca)}, are in the order of Ca> Mg> Cl->Na>K.

Heavy Metals (iron Fe, zinc Zn, chromium Cr, cadmium Cd, copper Cu, manganese Mn) **-** The concentrations of heavy metals (iron Fe, zinc Zn, lead Pb, chromium Cr, Cadmium Cd, Copper Cu and Manganese Mn, as follows: Iron (Fe) ranged from 0.08-0.72Mg/l with mean value of 0.38Mg/l. Zinc (Zn) ranged from 0.021-0.051Mg/l with mean value of 0.03Mg/l. Chromium (Cr) ranged from 0.016-0.086Mg/l with mean value of 0.04Mg/l. Cadmium (Cd) ranged from 0.001-0.009Mg/l with mean value of 0.01Mg/l. lead was not detected. Copper (Cu) ranged from 0.00-0.006Mg/l with mean value of 0.002Mg/l. Manganese (Mn) ranged from 0.002-0.009Mg/l with mean value of 0.005Mg/l. The concentrations of heavy metals in the samples are relatively lower than results of Sabo *et al*.(2020) which reported as follows: Lead (0.01mg/l), Zinc (0.91mg/l), Iron (0.l6mg/l), Manganese (0.29mg/l) and Chromium (0.05mg/l) in borehole waters located within the industrial areas in Kano Metropolis. This was attributed less industrial activities in the Gwagwalada Area Council. However, improper management was observed to be responsible of presence of heavy metals like Cr, Cd and Cu in the study area.

Suitability of the Borehole Water for Drinking Purpose

The suitability of water samples for drinking purpose was ascertained by comparing the water properties with the WHO standard for drinking purpose (WHO, 2010 (Table 2).

Table 2 shows the concentration of the physical and chemical properties of borehole water, the NSDWQ and WHO standard for drinking purpose. It shows water properties and regulatory standards as follows:

pH -The concentration of pH ranged from 6.83-7.86. This value is within the ranges of 6.5-8.5 NSDWQ and 6.5-9.2 standard set by WHO for domestic purpose. Thus, borehole water in Gwagwalada Area Council is safe for domestic purpose in term of pH.

Electrical Conductivity

The E.C of borehole water in Gwagwalada Area Council ranged from 132-184 µS/cm^3 with mean value of 151.50µS/cm is below ≥ 1000µS/cm3 NSDWQ and ≥1500µS/cm^3 standards set by WHO for domestic purpose (WHO, 2010). Thus, the EC of borehole water in Gwagwalada Area Council fall short of regulatory standards. Therefore, water from borehole water in Gwagwalada Area Council is not safe for drinking purpose in terms of EC. Igwemmar *et al*. (2013) also recorded E.C. below World Health Standard in four boreholes.

Parameters	Unit	Range	Mean	NSDWQ, 2007	WHO, 2010
pH		6.83 -7.86	7.23	6.5-8.5	6.5-9.2
E.C	µS/cm^3	132 – 184	141.50	≥1000	≥1500
TDS	mg/l	1.4 - 3.1	2.13	500	500
TSS	mg/l	0.02 - 0.30	0.09	500	-
Turbidity	NTU	0.36 - 0.71	0.56	≤10	≤5
T. Hardness		6.12 - 19.72	11.38	500	200
K		3.03 - 4.84	3.45		100
Na		3.20 - 6.30	4.39	200	60
Cl-		1.03 - 16.86	8.15	250	5
Ca		18.04 - 43.75	28.09	75	75
Mg		10.07 - 12.23	11.14		30
Fe		0.08 - 0.72	0.38		0.1
Si	mg/l	0.016 - 0.06	0.04		
Zn		0.031 - 0.061	0.03		5
Cr		0. 0.006 - 0.008	0.04		0.05
Cd		0.001 - 0.009	0.006		0.01
Pb		ND			
Cu		0.00 - 0.06	0.02		0.05
Mn		0.002 - 0.009	0.005		0.5

Total Dissolved Solids, Turbidity and Hardness

The concentration of TDS is within the regulatory standard for drinking purpose. TDS ranged from 1.4-3.1mg/l. Thus, all values are below 500 Mg/l limit set by WHO (2010). The concentrations of turbidity is within the acceptable limit for drinking purpose ≤5NTU set by WHO for domestic purpose and the ≤10 NTU NSDWQ, as it ranged from 0.36-0.71NTU. Therefore, all sampled borehole water are safe for drinking purpose in terms of turbidity. T. Hardness also meet regulatory standards as it ranged from 6.12-19.72mg/l and thus, 500 mg/l and 200 mg/l limit set NSDWQ and WHO respectively.

Mineral Nutrients (K, Na, Cl, Mg and Ca)

The concentrations of these minerals K, Na, Cl, Mg and Ca were generally below their regulatory standard. Potassium (K) ranged from 3.03-4.84mg/l but WHO standard for domestic purpose is l00mg/l. Sodium (Na) ranged from 3.20-6.30mg/l but WHO standard for domestic purpose is 60mg/l and national standard is 200mg/l. Chloride ranged from 1.03-16.86mg/l but NSDWQ is 250mg/l. Calcium (Ca) ranged from 18.04-43.75mg/l but WHO standard for domestic purpose is 75mg/l. Magnesium (Mg) ranged from 10.07-12.23mg/l but WHO standard for domestic purpose is 30mg/l.

Heavy Metals (Fe, Si, Zn, Pb, Cr, Cd, Cu and Mn,)

The concentrations of heavy metals were generally low but some samples fall short of regulatory standards for drinking purpose. The concentration of Iron (Fe) was higher in sample(s) than the WHO standard of 0.1Mg/l as it ranged from 0.08-0.72\mg/l. The concentrations of Zinc (Zn) were generally lower than the WHO standard of 5Mg/l as it ranged from 0.031-0.061Mg/l. Chromium ranged from 0.006-0.008Mg/l, the range meets the limit of 0.05 mg/l set by WHO for drinking purpose. The concentration of cadmium 0.001-0.009mg/l is lower than 0.05mg/l limit, set by WHO for drinking purpose. Pb was not detected in all the samples, thus, borehole water in Gwagwalada is safe for drinking purpose in terms of lead. Copper ranged from 0.00-0.06mg/l, the WHO set standard for domestic purpose is 0.05 mg/l, so sample(s) fall short of WHO set standard for drinking purpose. Manganese (Mn) ranged from 0.02-0.0.09Mg/l, the WHO set standard for domestic purpose is 0.5 mg/l, so all samples meet WHO set standard for domestic purpose.

CONCLUSION AND RECOMMENDATIONS

Most water samples are safe for drinking purpose, however, some samples fell short of the safety standards for drinking purpose in terms of E.C. and Fe. Data from the survey shows that, water sample were slight acidic (6.83) to slight alkalinity (7.86). E.C. was low and ranged from 132-184μS/cm^3. Heavy metals except Fe were within acceptable limit in all samples. Samples from Dobi, Ibwa and Tungan Majen fall short of regulatory standards for drinking purpose. It is therefore, recommended that the borehole water from Dobi, Ibwa and Tungan Majen should treated before consumption.

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