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THE SUITABILITY OF WELL WATER FOR DOMESTIC PURPOSE, IN GWAGWALADA AREA COUNCIL ABUJA NIGERIA

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ABSTRACT

Water wells are usually dug by artisans who lack professional skills. Such wells are used at various homes in Gwagwalada Area Council of Abuja for domestic purpose, on the assumption that underground water is safe. Thus, the suitability of such well water was assessed. The objectives were to assess their properties and compare with regulatory standard for domestic purpose. Thirty (30) water samples were purposely collected from six wards (Dobi, Ibwa, Paikon-Kore, Tungan Maje, Zuba and Ikwa). Five water samples were randomly collected from each ward for laboratory analysis. Laboratory results were statistically analyzed using range, mean, correlation and multiple determination coefficients. Suitability of water properties for domestic purposes was determined by comparing range and mean values with NSDWQ and WHO standard for domestic uses. Result showed that the concentrations of water properties ranges as follows: temperature (26.59-30.73^{o}C), pH (7.17-8.23), electrical conductivity EC (222-354 µs/cm3), TDS (12.14-21.54mg/l), Turbidity (0.29-0.93NTU) hardness (13.58-39.72mg/l), chloride Cl-(4.29-8.93mg/l), Fe (0.54-0.71mg/l) and Cu (0.02-0.06mg/l).Water samples generally had low electrical conductivity (222-354 µs/cm^{3}), and mineral nutrients but elevated concentration of some heavy metals. The twenty- three water quality parameters tested could explain 96% of the overall water quality leaving only 4% unexplained. All the samples fell short of regulatory standard in terms of EC, Fe and Cu while well water from Ikwa fell short of many heavy metals for domestic purpose. It was concluded that well water in Gwagwalada Area Council are not potable. Thus, treatment before direct consumption and precautionary use of well water were recommended for the residents.

KEYWORDS: Water quality, Heavy metals, Water pollution, Well,

1. INTRODUCTION

The provision of safe drinking water to the majority of the world's population is one of the greatest global challenges. In Nigeria, majority of the rural populace do not have access to tap water and therefore, depend on well, stream and river water for domestic use (Adeniyi and Abdullateef, 2019). Despite that, the expansion of population and economic activities especially in an urban setting like Abuja, Nigeria, has made surface water completely unsafe for domestic purpose (Chokpa, 2018). Consequently, many have resorted to underground water sources such as borehole and well water, with the notion that underground water is safe for drinking purpose. However, the safety of underground water is still questionable due to possible percolation of leachates from waste dumps and other sources of contamination like sewage system. Though, there is proliferation of borehole drilling in the Federal Capital Territory in general (Federal Capital Development Authority (FCDA, 2018), well water is still the most common underground water source in the study area.

Water quality refers to the suitability of water for certain purpose; hence quality of drinking water is the suitability of water for drinking and domestic uses. A good quality (safe) drinking water is that which is aesthetically acceptable and does not contain pathogenic agents and dangerous chemical substances. Domestic uses (drinking, cooking, bathing, washing and sanitation) are the fundamental and most important uses of water that must meet some standard, both in quantity and quality (Awaisu, *et al.,* 2019). Safe drinking water must be risk-health free such that a well-informed individual need not be concerned about it, nor find any rational basis to change his/her behavior to avoid a negligible but non-zero risk (World Health Organization WHO, 2010). Drinking water must be 'wholesome' and this is defined in law by standards for a wide range of substances,

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organisms and properties of water in regulations. The standards are set to be protective of public health and the definition of wholesome reflects the importance of ensuring that water quality is acceptable to consumers (Jidauna *et al*., 2017). There are different standards to determine the suitability of water for certain uses.

However, WHO standard is the most acceptable and commonly used. Thus, the World Health Organization Guidelines for Drinking Water Quality (WHO, 2010; 2015) were adopted for this study.

Water quality assessment is a very complex subject, in part because water is a complex medium, intrinsically tied to the ecology of the planet (Kolo *et al.,* 2009). To determine water quality therefore, several parameters must be examined. The complexity of water quality assessment as a subject is reflected in the many types of measurements of water quality. Among the key parameters listed by WHO (2011) for determination of water quality for domestic use are conductivity, pH, Color of water, taste and odour, turbidity, total suspended solids (TSS) and hardness.

Public in general, judges the quality of water supplied based on its appearance, taste, and odour at the point of its use. Although appearance, taste, odour etc are useful indicators of the quality of drinking waters, their presence does not necessarily make water unsafe to drink. In the same way, the absence of any unpleasant qualities does not guarantee water to be safe for consumption (Okoro *et al.,* 2017). However, suitability in terms of public health is determined by microbiological, physical, chemical and radiological characteristics. Also a number of chemical contaminations (both organic and inorganic) are found in water. These causes health problems in the long run and therefore detailed analysis are warranted.

Thus, several researches have been carried out on water quality and its safety for domestic use. Consequently, there are lots of literature on water quality and safety. For example Jidauna *et al*., (2017) assessed water quality of selected water sources in Dutsinma town, Katsina State, Nigeria. Result showed that tap water has pH value (4.61) which is acidic while the rest are within the approved standard. Dam had the lowest electrical conductivity (50.25µ/cm) and 56.15mg/l for total dissolve solute. However, calcium concentration appears lower for all water sources when compared to the WHO and SON standards for water quality. It was recommended that periodic monitoring of water quality and effective waste management system are required to improve the general water quality in the town. Then, by implication, this study is necessary based on the recommendation of Jidauna *et al*., (2017).

Shalom *et al.,* (2011) assessed water quality in Canaan land Ota Southwest Nigeria. In this study, water points in Canaan land, Ota, and nearby Iju River were analyzed for biological and physicochemical properties including heavy metal content. They reported that the water samples were slightly acidic (5.96 – 6.54) except the bottled/ sachet Hebron water and Iju River water. The results were compared against drinking water quality standards laid by World Health Organization (WHO) and Nigerian Standard for Drinking Water (NSDW). The potable water samples were within the standards for consumable water and so are considered safe for human consumption. The surface waters, on the other hand, have high levels of total dissolved solids, conductivity and salinity. The BOD of the effluent water showed that the water was contaminated and the use of the water for domestic purposes by the inhabitants could lead to hazardous side effects.

Chukwu (2008) reported a study on the ground water contamination from abattoir waste in Minna, Niger State. The examined wells with indicated physical, chemical and organic parameters that surpassed the upper limits set by WHO. The waters are by and large hard, containing elevated concentrations of calcium carbonate (CaCO3), magnesium carbonate (MgCO3), sulfates, nitrates, phosphates and heavy metals. Similarly, Ezeribe *et al.,* (2012) found that most of the parameters determined did not exceed the permissible limit of the World Health Organization (WHO, 2006). Turbidity levels, nitrates and fluoride concentrations in Dass, and Langtang North exceeded the WHO standard specified for drinking water.

Okoro *et al.,* (2017) carried out a comparative analysis of three borehole water sources in Nsukka urban area, Enugu State, Nigeria. Samples were collected from three locations within the area and analysed for some physico-chemical and microbial parameters, which were compared with the Nigerian Standard for Drinking Water Quality (NSDWQ) and the World Health Organization (WHO) standard for compliance evaluation. The physicochemical parameters included pH, Hardness, Total Solids, Alkalinlity, Turbidity, Sulphate, Phosphate, Silica, Cu, Pb, Fe, Residual Chlorine and Chloride with results ranging from 6.29-6.43, 15-483mg/l, 41.4-227.2mg/l, 0.2-0.5NTU, 12.48-17.92mg/l, 0.6-1.3mg/l, 0.12-0.29mg/l, 0.00-0.25ppm, 0.1630-0.2853ppm and 64.98-78.61mg/l respectively. All the physicochemical parameters were within the standard limits recommended by WHO and NSDWQ, except for the following: pH, Hardness and Pb.

Behailu *et al.,* (2017) determined the level of common cations, anions, heavy metals and physical parameters in drinking water supply system in Konso and its surrounding area, Southwestern Ethiopia. Water samples were collected from 23 different locations in the area where there is hand pump or motorized supply system that are used for drinking purpose. Collected samples were analyzed for physicochemical parameters including total alkalinity, Temperature, pH, Electrical Conductivity, Total dissolved solids, Turbidity, Alkalinity, Total hardness and Total suspended solids. Common cations (Li^+, K^+, Na^+, Ca^{2+} and Mg^{2+}), Common anions (NO^{3-}, SO_4^{2-}, PO_4^{2-}, F^- and Cl^-) and Heavy metals (Pd, Ni, Mn, Pb, Co, Zn, Cu) were analyzed. The results were compared with some national and international standards for drinking water. Accordingly, the results obtained showed that most of the physical and some common ions and heavy metals were within the accepted range of the guideline recommended by WHO.

Samaila *et al*., (2015) assessed water quality of hand dug wells used for domestic purposes in Vandekya, Benue State, Nigeria to determine the suitability of well water in the area for domestic use. The study recorded that most of the well waters had their properties within the permissible limit for drinking purpose set by World Health Organization. But some wells have turbidity and iron concentration greater than the WHO limit for drinking water.

Despite the abundance of literature in the topic of water quality, little attention has been paid to well water, which currently serves many domestic purposes including drinking in Gwagwalada Area Council Abuja, Nigeria. Thus, there is need to assess the suitability of well water for domestic purpose, in Gwagwalada Area Council Abuja, Nigeria as carried out in this study. The objectives were to assess the properties of well water and determine the suitability of well water properties for domestic purpose in Gwagwalada Area Council Abuja, Nigeria.

2. MATERIALS AND METHODS

Gwagwalada Area Council is one of the six area councils in the Federal Capital Territory which, according to the master plan of the FCT, is designated as the industrial zone. Gwagwalada is located between Latitudes $8^0$55' and 9^0 00' North and Longitudes 7^0 00'N and 7^0 05'E. The Area Council has ten political wards (Adeniyi and Abdullateef, 2019). The centrality of the town in relation to other Area Council Headquarters makes it influential and important in various socio-economic activities. It is where the University of Abuja, Abuja University Teaching Hospital and School of the Gifted are located. Consequently, there has been influx of people to Gwagwalada Area Council in recent years. This also increased the water demand which the Government have not been able to meet the demand. Thus, households have resorted to sourcing underground water by digging wells to have access to water for domestic uses.

Thirty (30) water samples were collected from wells in six purposely selected wards in the in the study. The selections of the wards for well sampling were based on heavy reliance of well water for domestic use among wards that currently lack public water supply. Thus, Dobi, Ibwa, Paikon-Kore, Tungan Maje, Zuba and Ikwa were selected. These wards according to the report of (Adeniyi and Abdullateef, 2019) are not linked with public tap water supply. Five water samples were randomly collected from each of the six selected wards and taken to laboratory for analysis. The selections of wells sampled were based on use. Wells used for drinking purpose was given preference to others. The uses and conditions of wells sampled were carefully observed at the course of sampling.

The water samples were stored in 150cl plastic bottles, pre-cleaned with distilled water and rinsed three times with the sample water. Each sample was labeled with the name of the ward and transported immediately to the Abuja Water Board Laboratory for analysis.

3. RESULTS AND DISCUSSIONS

Result in t**able 1 present the physical and chemical properties of well water in the study area as follows:**

Temperature and pH

Temperature recorded ranged from 26.59-30.73^{o}C with mean value of 28.04^o C. The concentration of pH in the water ranged from 7.17-8.23 with mean value of 7.81. The range of pH is similar to the report of Tsegay and Haftom (2016) that reported 7.14 – 8.64 in reservoir water.

Electrical Conductivity (EC)

The concentration of electrical conductivity in water samples ranged from 222-354μ^s/cm^3 with mean value of 261.00μ^s/cm^3. The concentration of electrical conductivity is highest (354 μ^s/cm^3) in sample collected Dobi while the water sample collected from Ikwa has the least concentration of electrical conductivity (240 μ^s/cm^3).

TDS, TSS and Turbidity

The concentration of Total Dissolved Solids (TDS) ranged from 12.14-21.54 Mg/l with mean value of 14.56 Mg/l. The Total Suspended Solids ranged from 0.26-1.33 Mg/l with mean value of 0.49 Mg/l. This is in close range with the report of (Tsegay and Haftom, 2016) that reported 0.91 – 1.77 Mg/l in reservoir water. Turbidity ranged from 0.29-0.93 Mg/l with mean value of 0.46 Mg/l.

Total Hardness

The concentration of total hardness ranged from 13.58-39.72 Mg/l with mean value of 23.87 Mg/l. 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) reported a range of 29–94 Mg/l and Akpan-Idiok (2012) reported a range of 6.41-19.20 Mg/l.

Minerals Nutrients (K, Na, Cl-, Mg, Ca and NO-3)

The concentrations of minerals nutrients in well water in the study area are low except for Chloride, magnesium and calcium. The concentrations are as follows: Potassium (K) ranged from 3.05-5.09 Mg/l with mean value of 4.10 Mg/l. Sodium (Na) ranged from 4.11-5.65Mg/l with mean value of 5.08 Mg/l. Chloride (Cl-) ranged from 4.29-8.93 Mg/l with mean value of 6.62 Mg/l. Magnesium (Mg) ranged from 9.03-17.86 Mg/l with mean value of 12.53Mg/l. Calcium (Ca) ranged from 8.04-21.86 Mg/l with mean value of 14.34 Mg/l. Nitrate (NO^-3) ranged from 1.47-2.53Mg/l with mean value of 1.73Mg/l. Phosphate (PO^-4) ranged from 0.27-0.73 Mg/l with mean value of 0.51 Mg/l. The mean concentrations of mineral nutrients{potassium(K),sodium(Na), chloride(Cl-), magnesium (Mg), calcium (Ca), nitrite (NO^-_3) and phosphate (PO^-_4)}are in the order of Ca> Mg> Cl^->Na>K> NO^{-3}> PO^{-4}.

HEAVY METALS (IRON FE, SILICON SI, ZINC ZN, LEAD PB, CHROMIUM CR, CADMIUM CD,

Copper Cu, Manganese, Mn, Fluorine F, and Boron B)

The concentrations of heavy metals are as follows: Iron (Fe) ranged from 0.54-0.71Mg/l with mean value of 0.61 Mg/l. Silicon (Si) ranged from 0.01-0.06Mg/l with mean value of 0.02Mg/l. Zinc (Zn) ranged from 0.01-0.09Mg/l with mean value of 0.03Mg/l. Lead (Pb) ranged from 0.002-0.004Mg/l with mean value of 0.003Mg/l. Chromium (Cr) ranged from 0.006-0.021Mg/l with mean value of 0.013Mg/l. Cadmium (Cd) ranged from 0.002-0.039Mg/l with mean value of 0.022Mg/l. Copper (Cu) ranged from 0.02-0.06Mg/l with mean value of 0.028Mg/l. Manganese (Mn) ranged from 0.003-0.06Mg/l with mean value of 0.024 Mg/l. Fluorine (F) ranged from 0.001-0.002Mg/l with mean value of 0.002 Mg/. Boron (B) ranged from 0.024-0.051Mg/l with mean value of 0.026 Mg/l. The concentrations of heavy metals (iron Fe, silicon Si, zinc Zn, lead Pb, chromium Cr, Cadmium Cd, Copper Cu, Manganese, Mn, Fluorine F, and Boron B) are generally low and similar to the report of Okoro *et al.,*(2017).Though, the concentrations of heavy metals are low, heavy metals can be poisonous at low concentration.

Table 1: The Physical and Chemical Properties of Well Water in Gwagwalada Area Council Abuja

Parameter	Dobi	Ibwa	Paikon-Kore	Tungan Maje	Zuba	Ikwa	Range	Mean
Temp. (^{o}C)	26.96	27.32	28.98	30.73	26.59	27.66	26.59-30.73	28.04
pH	8.14	7.17	7.41	7.92	8.01	8.23	7.17-8.23	7.81
E.C(µs/cm3)	354	242	254	254	240	222	222-354	261.00
TDS(Mg/l)	14.45	13.16	12.97	13.08	12.14	21.54	12.14-21.54	14.56
TSS(Mg/l)	0.37	0.29	0.39	0.26	0.28	1.33	0.26-1.33	0.49
Turbidity(NTU	0.37	0.29	0.26	0.45	0.47	0.93	0.29-0.93	0.46
Hardness(Mg/l)	22.06	13.58	39.72	19.46	19.26	29.12	13.58-39.72	23.87
K Mg/l	4. 03	4.06	4.13	4.16	5.09	3.05	3.05-5.09	4.10
Na Mg/l	4.11	5.62	5.03	5.06	5.01	5.65	4.11-5.65	5.08
Cl- Mg/l	6.54	5.42	4.29	7	8.93	7.54	4.29-8.93	6.62
Mg Mg/l	2.03	2.83	17.86	6.21	11.22	17.04	2.03-17.86	9.53
Ca Mg/l	20.03	10.75	21.86	13.25	8.04	12.08	8.04-21.86	14.34
NO^{-}_{3} Mg/l	1.83	0.96	1.82	2.53	1.75	1.47	1.47-2.53	1.73
Fe Mg/l	0.62	0.71	0.62	0.55	0.54	0.64	0.54-0.71	0.61
Si Mg/l	0.01	0.02	0.017	0.03	0.02	0.06	0.01-0.06	0.03
Zn Mg/l	0.01	0.031	0.013	0.09	0.021	0.017	0.01-0.09	0.03
Lead Mg/l	0.002	0.003	0.004	0.002	0.004	0.003	0.002-0.004	0.003
Cr Mg/l	0.014	0.006	0.011	0.011	0.013	0.021	0.006-0.021	0.013
Cd Mg/l	0.005	0.002	0.013	0.031	0.042	0.039	0.002-0.039	0.022
Cu Mg/l	0.02	0.02	0.03	0.02	0.02	0.06	0.02-0.06	0.028
Mn Mg/l	0.006	0.044	0.011	0.022	0.003	0.055	0.003-0.06	0.024
F Mg/l	0.002	0.001	0.001	0.002	0.002	0.002	0.001-0.002	0.002
B Mg/l	0.017	0.034	0.025	0.024	0.004	0.051	0.024-0.051	0.026

The concentration of particular parameter can influence the concentration of other parameters. For instance high concentration of heavy metals may increase acidity of water. Thus, the twenty-three (23) parameters were correlated to determine the relationships that exist between parameters (Table 2).

Table 2: Correlation Matrix of Well Water Properties

	Temp	pH	EC	TDS	TSS	Turb.	Hard.	K	Na	Cl-	Mg	Ca	NO^-_3	Fe	Si	Zn	Cont'd
Temp.	1																
pH	-0.13	1															
EC	-0.18	0.24	1														
TDS	-0.13	0.51	-0.22	1													
TSS	-0.14	0.47	-0.34	0.98	1												
Turb	-0.1	0.69	-0.39	0.9	0.9	1											
Hard	0.24	0.02	-0.07	0.27	0.37	0.11	1										
K	-0.17	-0.18	0.53	-0.87	-0.82	-0.62	-0.32	1									
Na	0.1	-0.35	-0.92	0.37	0.44	0.4	-0.05	-0.72	1								
Cl-	-0.31	0.74	-0.14	0.2	0.2	0.57	-0.42	0.25	-0.02	1							
Mg	0.12	0.11	-0.57	0.41	0.56	0.44	0.81	-0.31	0.38	-0.02	1						
Ca	0.25	-0.1	0.60	-0.07	-0.09	-0.38	0.67	-0.24	-0.57	-0.7	0.11	1					
NO^-_3	0.69	0.43	0.23	-0.24	-0.26	-0.04	0.18	0.23	-0.48	0.2	0.03	0.26	1				
Fe	-0.3	-0.55	-0.02	0.87	0.24	-0.08	-0.05	-0.54	0.38	-0.59	-0.16	0.12	-0.82	1			
Si	0.14	0.41	-0.61	0.87	0.89	0.93	0.17	-0.8	0.65	0.33	0.51	-0.37	-0.08	0.06	1		
Zn	0.79	-0.02	-0.21	-0.25	-0.3	-0.05	-0.38	0.09	0.15	0.12	-0.3	-0.27	0.61	-0.39	0.12	1	
Lead	-0.31	-0.34	-0.54	-0.15	0.02	-0.08	0.42	0.4	0.35	-0.04	0.67	-0.14	-0.34	-0.04	-0.04	-0.48	
Cr	-0.17	0.83	-0.05	0.83	0.41	0.88	0.39	-0.53	0	0.49	0.52	0	0.13	-0.22	0.7	-0.29	
Cd	0.1	0.61	-0.55	0.33	0.41	0.69	0.06	0.06	0.29	0.78	0.52	-0.56	0.36	-0.67	0.62	0.23	
Cu	-0.05	0.37	-0.55	0.94	0.98	0.85	0.5	-0.83	0.5	0.1	0.69	-0.03	-0.23	0.23	0.89	-0.29	
Mn	0.04	-0.11	-0.54	0.71	0.68	0.58	-0.11	-0.86	0.8	-0.07	0.13	-0.36	-0.52	0.63	0.76	0.083	
F	-0.05	0.95	0.21	0.33	0.27	0.59	-0.23	0	-0.34	0.84	-0.09	-0.28	0.51	-0.64	0.33	0.21	
B	0.16	-0.05	-0.40	0.8	0.78	0.58	0.22	-0.98	0.65	-0.27	0.3	-0.01	-0.39	0.63	0.76	-0.02	

Pb	Cr	Cd	Cu	Mn	F	B
-0.05	1					
0.24	0.6	1				
0.14	0.8	0.42	1			
-0.15	0.23	0.06	0.66	1		
-0.43	0.66	0.64	0.16	-0.14	1	
-0.17	0.36	-0.02	0.79	0.93	-0.18	1

Table 2 present the correlation matrix of parameters. For examples, temperature has strong positive relationship with NO^-_3 and Zn (r = 0.69 and 0.79) respectively. pH has strong positive relationship with TDS, turbidity, Cl-, Cr, Cd and F (r =0.51, 0.69, 0.74, 0.83, 0.62 and 0.95) respectively. EC has strong negative correlation with Na, Mg, Si, Pb, Cd, Cu and Mn (-0.92, -0.57,-0.61, -0.54, -0.55, -0.55 and -0.54) respectively. TDS has strong positive relationship with TSS, turbidity, Fe, Si, Cr, Cu, Mn and B.

Having correlated the parameters to determine their relationships, multiple regressions (R) for the various correlation coefficients (r) was computed to determine the overall strength of the parameters in ascertaining the quality of well water in the study area (Table 3).

Table 3: Coefficient of Determination of Water Quality Parameters

Statistics	Result
Multiple Correlation (R)	0.98
Coefficient of Multiple Determination (R^2)	0.96 (96%)
Standard Error of Estimate (SEE)	0.005

The Coefficient of Multiple Determination (R^2) being 96% means that the twenty- three water quality parameters tested can explain 96% of the overall water quality leaving only 4% unexplained. Thus, the variables are good enough to judge the well water quality in the study area. Thus, the suitability of the well water for domestic purpose was ascertained at 96% ± 0.005.

The Physical and Chemical Properties of Well Water in Gwagwalada Area Council and Regulatory Standard for Domestic Purpose.

Table 4 present the properties of well water in Gwagwalada Area Council and regulatory standard for domestic purpose.

Table 4:Properties of Well Water in the Study Area and Regulatory Standard for Domestic Purpose

Parameters	Range	Mean	NSDWQ(2007)	WHO Standard (2015)
Temp.(°C)	26.59-30.73	28.04	<40	>20<40
pH	7.17-8.23	7.81	6.5-8.5	6.5-9.2
E.C(µs/cm3)	222-354	261	≥1000	≥1500(µs/cm3)
TDS(Mg/l)	12.14-21.54	14.56	500	500
TSS(Mg/l)	0.26-1.33	0.49	500	-
Turb.(NTU	0.29-0.93	0.46	≤10	≤5
T. Hardness (Mg/l)	13.58-39.72	23.87	500	200
K(Mg/l	3.05-5.09	4.1		100
Na(Mg/l	4.11-5.65	5.08	200	60
Cl-(Mg/l	4.29-8.93	6.62	250	5
Mg(Mg/l	2.03-17.86	9.53		30
Ca(Mg/l	8.04-21.86	14.34	75	75
NO^-_3(Mg/l	1.47-2.53	1.52	50	45
Fe(Mg/l	0.54-0.71	0.61		0.1
Si(Mg/l	0.01-0.06	0.03		
Zn(Mg/l	0.01-0.09	0.03		5
Lead(Mg/l	0.002-0.004	0.01		1
Cr(Mg/l	0.006-0.021	0.013		0.05
Cd(Mg/l	0.002-0.039	0.022		0.01
Cu(Mg/l	0.02-0.06	0.04		0.05
Mn(Mg/l	0.003-0.06	0.04		0.5
F(Mg/l	0.001-0.002	0.002		0.9
B(Mg/l	0.024-0.051	0.03	-	-

Table 4 shows the range and mean concentrations of water properties and the NSDWQ and WHO standard for domestic purpose. It shows water properties regulatory standard as follows:

Temperature and pH

The mean records of water temperature is 28.04^0c .This value is below the maximum limit of <40^0c set by NSDWQ and also lies within the range>20^0c <40^0c set by WHO. The concentration of pH ranged from 7.17-8.23. The range is within the ranges of 6.5-8.5 NSDWQ and 6.5-9.2 standard set by WHO for domestic purpose. Thus, water from wells in Gwagwalada Area Council is safe for domestic purpose in terms of temperature and pH.

Electrical Conductivity (E.Cμ^s/cm^3)

The electrical conductivity of well water in the area range 222-354μs/cm^3 with mean value of 261.00μs/cm which is below ≥1000μ^s/cm3 NSDWQ and ≥1500μ^s/cm^3 standard set by WHO for domestic purpose. Thus, the EC of well water in Gwagwalada Area Council fall short of regulatory standard for domestic purpose. Therefore, water from Gwagwalada Area Council is not safe for domestic purpose in terms of EC.

Total Dissolved Solids (TDS) and Turbidity

The concentration of Total Dissolved Solids (TDS) is within the regulatory standard for domestic purpose. The TDS ranged from 12.14-21.54Mg/l. Thus, all values are below 500 Mg/l limit set by WHO. The mean concentration of turbidity was 0.46 Mg/l. Thus, the turbidity of water in Gwagwalada Area Council is within acceptable limit of ≤5NTU set by WHO for domestic purpose and the ≤10 NTU NSDWQ.

Total Hardness

Total hardness of all samples in Gwagwalada Area Council is within the NSDWQ and WHO standard for domestic purpose. Total hardness ranged from 13.58-39.72 Mg/l. This range of value is below the maximum limits of 200Mg/l set by WHO for domestic purpose and the 500Mg/l National Standard for Drinking Water Quality. Therefore, water in Gwagwalada Area Council is safe for domestic purpose in terms of total hardness.

Mineral Nutrients (K, Na, Cl, Mg, Ca and NO_3^-)

The concentrations of these minerals K, Na, Cl, Mg, Ca, $NO_3^-$and PO_4^-in Gwagwalada Area Council were generally below their regulatory standard. Potassium (K) ranged from 3.05-5.09Mg/l but WHO standard for domestic purpose is I00Mg/l. Sodium (Na) ranged from 4.11-5.65Mg/l but WHO standard for domestic purpose is 60Mg/l and national standard is 200Mg/l. Chloride ranged from 4.29-8.93Mg/ but NSDWQ is 250Mg/l. Magnesium (Mg) ranged from 2.03-17.86Mg/l but WHO standard for domestic purpose is 30Mg/l. Calcium (Ca) ranged from 8.04-21.86Mg/l but WHO standard for domestic purpose is 75Mg/l. Nitrate (NO^-_3) ranged from 1.47-2.53Mg/l but WHO standard for domestic purpose is 45g/l. Therefore, Water in Gwagwalada Area Council fall short of regulatory standard for domestic uses in terms of minerals K, Na, Cl, Mg, Ca and $NO\text{-}_3$.

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

The concentrations of heavy metals in water in Gwagwalada Area Council were generally low but Fe and Cu fall short of regulatory standard for domestic purpose. The concentrations of Iron (Fe) were generally higher than the WHO standard of 0.1Mg/l as it ranged from 0.54-0.71Mg/l. The concentrations of Zinc (Zn) were generally lower than the WHO standard of 5Mg/l as it ranged from 0.01-0.09Mg/l. Lead concentrations were also generally lower than the WHO standard of 0.05Mg/l as it ranged from 0.003- 0.004Mg/l. Chromium ranged from 0.006-0.021Mg/l which is within the WHO set limit of 0.05 Mg/l. Copper ranged from 0.02-0.06Mg/l while the WHO set standard for domestic purpose is 0.05 Mg/l, so sample(s)fall short of WHO set standard for domestic purpose. Thus, only well water from Ikwa with mean value of 0.06 mg/l fall short of WHO set standard for domestic purpose (Table 1). Manganese (Mn) ranged from 0.003-0.06Mg/l while the WHO set standard for domestic purpose is 0.5 Mg/l, so all samples in meet WHO set standard for domestic purpose. Fluorine (F) was generally lower than the WHO standard of 0.9Mg/l as it ranged from 0.001-0.002Mg/l.

The elevation of some heavy metal in well water was attributed to poor maintenance and poor sanitation witnessed mostly in Ikwa ward. Wells in Ikwa ward were not properly covered and some were covered with rusted metal cover (Plate1 and 2).

Plate 1: Well Without Cover in Ikwa ward
Source: Field work, 2019

Plate 1: Well Rusted Metal Cover in Ikwa ward
Source: Field work, 2019

4. CONCLUSION AND RECOMMENDATIONS

It was concluded that well water in Gwagwalada Area Council are not safe for domestic purposes especially for drinking. Data from the survey shows that water samples generally had low electrical conductivity (222-354 µs/cm^3), and nutrient but elevated concentration of some heavy metals. All samples fell short of regulatory standards in terms of EC, Fe and Cu, while well water from Ikwa fell short of many heavy metals for domestic purposes.

The following recommendations were made based on findings of this study:

i. Since the result showed that well water in the study area fall short of regulatory standard for domestic purpose, Gwagwalada Area Council should a matter of urgency provide potable water to the residents to avert possible illness that may result from the consumption of untreated well water. Residents should be cautious of activities/factors (exposure, geological location and slope) capable of polluting well water within the area.

ii. Future study should be conducted on the sources of heavy metals in well water especially Ikwa ward that fall short of many heavy metals for domestic purpose.

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