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RESEARCH ARTICLE

SEASONAL VARIATIONS IN THE PHYSICOCHEMICAL PARAMETERS OF DRINKING WATER IN MUBI-NORTH, GIREI AND MAYO-BELWA LOCAL GOVERNMENT AREAS OF ADAMAWA STATE, NIGERIA

Maitera N. O.[1,*], Milam .C.[2] and Amina M.K[3]

[1,2]Department of Chemistry, Modibbo Adama University of Technology, Yola, Nigeria

[3]Department of Chemistry, sch. of Secondary edu, Sc. Programme, Federal College of Education, Yola, Nigeria

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ABSTRACT

Physicochemical quality of drinking water in Mubi-North, Girei and Mayo-Belwa local government areas, Adamawa State Northeastern Nigeria was investigated. Water samples were collected using 100ml wide open plastic well sterilized (using distilled water). Sampling was done in the months of August-October for the wet season and January-March for dry season using a portable dissolved oxygen analyzer for DO. Hanna portable pH/EC/TDS/temperature meter for pH, conductivity, total dissolved solids and temperature at sample collection point. The results revealed that in well water during rainy season, the mean temperatures readings ranged from (29.30 – 30.71 ^oC), and dry season range was (30.33 – 31.12 ^oC) while (29.85 – 31.42 ^oC) and (30.39 – 33.19 ^oC) were recorded for bore-holes during rainy and dry seasons respectively, in well water during rainy season, the mean pH values ranged from (7.3 – 8.24), while during dry season it ranged from (8.68 – 9.36), for borehole water, during raining season ranged from (6.94 – 8.13) and during dry season, it ranged from (8.51 – 9.43). it was revealed that in well water during rainy season, the mean TDS values ranged from (377.67 – 617.00 PPM) and (568.56 – 630.00 PPM) during dry season, for borehole it ranged from (74.44 – 589.44 PPM) and (113.56 – 637.44 PPM) during rainy and dry seasons respectively. During rainy season, the mean conductivity values ranged from (283.25 – 462.75 $\mu S/cm^3$), and (426.42 – 472.50 $\mu S/cm^3$) during dry season while for borehole water it ranged from (55.83 – 478.08 $\mu S/cm^3$) and (85.17 – 442.08 $\mu S/cm^3$) for rainy and dry season. In well water during rainy season, the mean BOD values ranged from (1.60 – 2.48 mg/l), during dry season it ranged from (0.63 – 1.16 mg/l), for borehole water, during raining season, it ranged from (0.90 – 2.39 mg/l), while during dry season, it ranged from (0.47 – 0.59 mg/l). This study has shown through its findings that the physical parameter for drinking water in the study area are generally within the threshold values stipulated by WHO but fluctuates seasonally (rainy and dry). Hence, both wells and boreholes are suitable for drinking, domestic activities and healthy environment which promote primary productivity as at the time of this study.

INTRODUCTION

Water is essential to human life and the health of the environment. As a valuable natural resource, it comprises marine, estuarine, freshwater (river and lakes) and groundwater environments that stretch across coastal and inland areas. Water has two dimensions that are closely linked, these are quantity and quality. Water quality is commonly defined by its physical, chemical, biological and aesthetic (appearance and smell) characteristics. Water quality is a tool for water quality managers to protect public health, support the economy and maintain a rich ecosystem. The population growth and development of every community requires availability of quality ground water such as rivers, streams, lakes, wells, boreholes, spring etc.

***Corresponding author:* Maitera N. O.,**

Department of Chemistry, Modibbo Adama University of Technology, Yola, Nigeria.

Since lives depend solely on it. In most sub-Saharan African urban-rural communities, water is mostly used for domestic purposes (Dimowo, 2013). The quality of ground water can best be determined by analyzing the physicochemical properties of such water (FEPA, 2014) . had documented that the qualities of these water bodies are at risk following the release of effluent from municipal waste, agricultural activities and industrial points. Some of these effluents may contain organic and inorganic pollutants as documented by (Idowu et al 2013). Human activities on the river beds usually introduced inorganic substances that are non-biodegradable and have been reported to create an environmental burden of considerable magnitude which effects are felt on the quantity and quality of water resources over a wide range of space and time scales (FEPA, 2014) A healthy environment is one in which the water quality supports a rich and varied community of organisms and protects public health.

Our water resources are of major environmental, social and economic value to human and if water quality becomes degraded this resource will lose its value. Water quality is important not only to protect public health, water provides ecosystem habitats, is used for farming, fishing and mining, and contributes to recreation and tourism. If water quality is not maintained, it is not just the environment that will suffer. The commercial and recreational value of our water resources will also diminish (EPA, 2017). Normally, water required for domestic consumption should be of high quality, possess high degree of purity and should be free from suspended and dissolved impurities, bacteria, pathogens, heavy metals, toxic organic compounds etc. both dug wells and boreholes water are expected to be less contaminated. However, there are possibilities of introduction of contaminants, depending upon management and the temperature gradient of the water environment (Priscilla, 2010). Murtala *et al.* (2014) Katsina Urban Area, Katsina State, Nigeria, studies by Likambo (2014) on physiochemical properties, Ahmed (2014) research aimed at assessing the ground water quality at Abubakar Tatari Ali Polytechnic, Bauchi, Report from Odiba (2017), boreholes and hand dug wells from Bantaji and Rafin-Kada settlements of Wukari L.G. were analyzed for fourteen physicochemical parameters, Christopher *et al.* (2014) reported the environmental impact of leachate pollutants on ground water samples from three boreholes located near a landfill at Akure, Nigeria, Hiremath *et al.* (2011) carried out seasonally analysis of the physicochemical parameters of 36 samples from different sources in Karnataka, Omofonmwan and Esigbe (2013) examined the effects of solid waste on the quality of underground water in Benin metropolis, Nigeria are of great value to this study. Since water is of necessity to man, animals and plants, it is of greater importance to assess its quality so as to proffer guidelines for its sustainable usage or make corrective steps to ensure its quality. This study is therefore aimed at assessing the physicochemical parameters of the major sources of drinking water (wells and boreholes) in the three selected local government areas in Adamawa, State, Nigeria.

MATERIALS AND METHODS

Study areas: The study areas for this research covered the following local government areas in Adamawa state: Mubi-North, Girie and Mayo-Belwa Located in the north eastern part of Nigeria and lies between latitude 7^{O} and 11^{O}, north of the equator and between longitude 11^{O} and 14^{O}east of the Greenwich meridian (Sanusi, 2017 cited Adebayo, 1999). Composite sampling was adopted in all the study areas. In Mubi-North north local government area, well1 is located at Shuwari Garden city (Sabon -layi) on latitude N10^{0}.16.045' and longitude E13.16.716, well 2 on latitude N10^{0}.16.591' and longitude E13.16.174', well 3 at Anguwan Qarkeje on latitude N10^{0}.16.162 and longitude E 13. 15. 667. Bole-hole point 1 is located at Shuware Qura'anic memorization school on latitude 10^{0}.16.311' and longitude E10^{0}.16 623' and longitude 13^{0}.16.311'.bore-hole 2 in Shuware primary school located on N10^{0}.16.667' and longitude E13^{0}.15, 119', bore-hole 3 at Coke-cola deport, Shagari low cost on latitude N10^{0}.16.162 and longitude E13^{0}. 15.661. In Girie local government area, well 1 is located in Bajabure, Latitude N 9^{0} 18. 340' and longitude E12^{0} 27.859', well 2 is located Latitude 9^{0} 18.278 and longitude 12^{0} 27.859, well 3 is located on latitude No 9^{0}.18.161' and longitude E12^{0} 27.922', bore-water 1 is located Samunaka Bajabure on latitude No9^{0} 18. 027' and longitude E012^{0}.28.087', bore-hole 2 is located on latitude N9^{0}18.152' and longitude E012^{0}.27.885', bore-hole 3 is on latitude 90.18.32^{0}' and E12^{0}27.829. Mayo-belwa local government area well 1 location is Labbare on latitude N9 ^{0}.06, 566 and 12^{0}.04.617', well 2 is located at Anguwan fada on latitude N9^{0}.03.663' and E12^{0}.03.138'well 3 at Labbare 11 on latitude N9^{0}.06.639' and longitude E12^{0} 04.671, bore-hole 1 at Masagamare Sabonlayi on latitude N9^{0}.05.402' and longitude E12^{0}.04.436', bore-hole 2 at kofar fada on latitude N90 03.738' and E12^{0} 03.249', bore-hole 3 at Wakili Buba ward on latitude N9^{0} 03.420' and E12^{0} 03.391. Table 1 shows the coding of the study areas

Water sampling and Duration for Physicochemical Parameters Determination: Water samples for physiochemical analysis were collected using 100ml wide open plastic well sterilized (using distilled water) from the various sampling points. 21 samples were collected every month from August-October for the rainy season and same numbers were collected from January-March during the dry season.

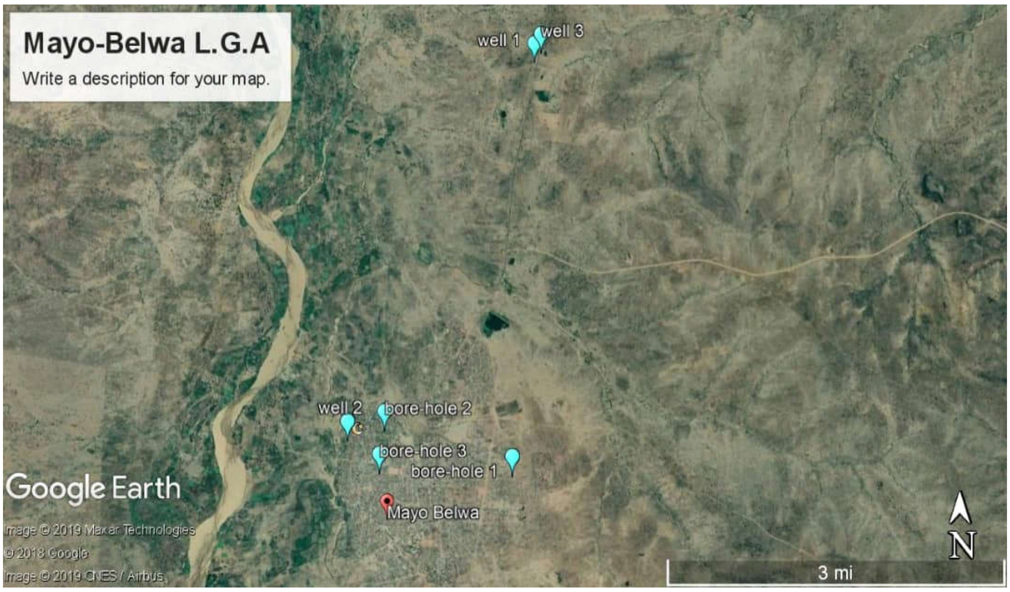
A total of 126 samples were collected across the study areas and at each sampling point, sample is transferred into 1L container earlier sterilized for onward transportation for laboratory work. Some of the Physical parameters were measured at the point of collection. These included temperature, specific conductivity, pH, total dissolved solid (TDS) and dissolved oxygen (DO) using a portable dissolved oxygen analyzer (model JPB-607) for DO. Hanna portable pH/EC/TDS/temperature meter (Model H19813-5) was used for pH conductivity, total dissolved solids and temperature at sample collection point following the manufacturer's instructions while others were determined in the laboratory. All data were collected, mean calculated and recorded at each of the sampling point.

RESULTS AND DISCUSSION

Data Analysis: Results were presented as mean ± SD. The Pearson's correlation analysis, Analysis of Variance (ANOVA) with Scheffe post hoc test and the student t-test were used for the statistical analyses of results obtained at 95% confidence level using Microsoft Excel 2007 package. Figure 1 above shows the mean temperatures values for the respective well and borehole water during the rainy and dry seasons in respect to the local government areas of study. The results showed that in well water during rainy season, the mean temperatures readings ranged from (29.30 – 30.71 ^{o}C). The highest temperature value was recorded in Mayo-Belwa while the least value was recorded in Mubi-North.

The temperature readings during dry season for well water across the sampled local government areas ranged from (30.33 – 31.12 ^{o}C), with the highest value recorded in Girei local government area, while the least temperature reading was recorded in Mubi-North local government area. All the temperature readings were within the permissible limit of 40.0 ^{o}C set by WHO. Analysis of variance of temperature readings for well water during rainy and dry season for the three local government areas showed significant difference at $p<0.05$. The temperature readings for borehole water in the study areas during rainy season ranged from (29.85 – 31.42 ^{o}C). The highest temperature value was recorded in Girei while least value was recorded in Mubi-North local government area.

Nos	codes	Areas	coordinates	
			N	E
1	MUBWW1	Shuwari Garden city	10^0.16.045'	13.16.716',
2	MUBWW2	Sabon-layi	10^0.16.591'	13.16.174',
3	MUBWW3	Anguwan Qarkeje	10^0.16.162'	13. 15. 667'.
4	MUBBHW1	Shuware Qura'anic memorization school	10^0.16.311'	13^0.16. 623',
5	MUBBHW2	Shuware primary school	10^0.16.667'	13^0.15, 119',
6	MUBBHW3	Coke-cola deport, Shagari low cost	10^0.16.162'	13^0. 15.661'
7	GIWW1	Bajabure 1	9^0 18. 340'	12^0 27.859'
8	GIWW2	Bajabure 2	9^0 18.278'	12^0 27.859'
9	GIWW3	Bajabure 3	9^0.18.161'	12^0 27.922'
10	GIBHW1	Samunaka	9^0.18.027'	12.28.087'
11	GIBHW2	Bajabure 1	9^0.18.152'	12.27.885'
12	GIBHW3	Bajabure 11	9^0.18.32'	12.27.829'
13	MBWW1	Labbare	9^0.06.566'	12.04.617'
14	MBWW2	Anguwan fada	9^0.03.663'	12.03.138'
15	MBWW3	Labbare 11	9^0.06.639'	12.04.671'
16	MBBHW1	Masagamare Sabon-layi	9^0.05.402'	12.04.436'
17	MBBHW2	kofar fada	9^0.03.738'	12.03.249'
18	MBBHW3	Wakili Buba	9^0,03.420'	12.03.391'



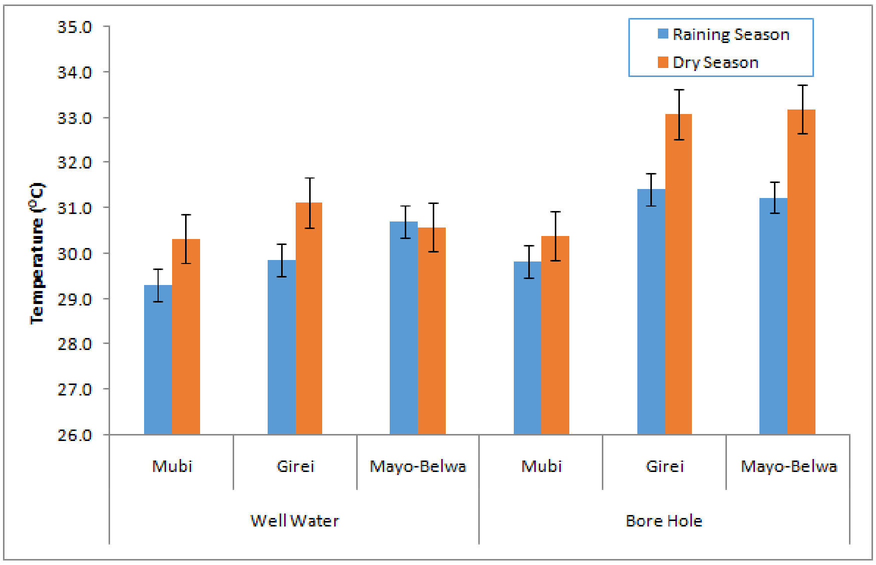


Figure 1. Mean Temperature Readings in Drinking Waters (Well & Borehole) in Mubi-North, Girei and Mayo-Belwa local government areas (Rainy & Dry Seasons)

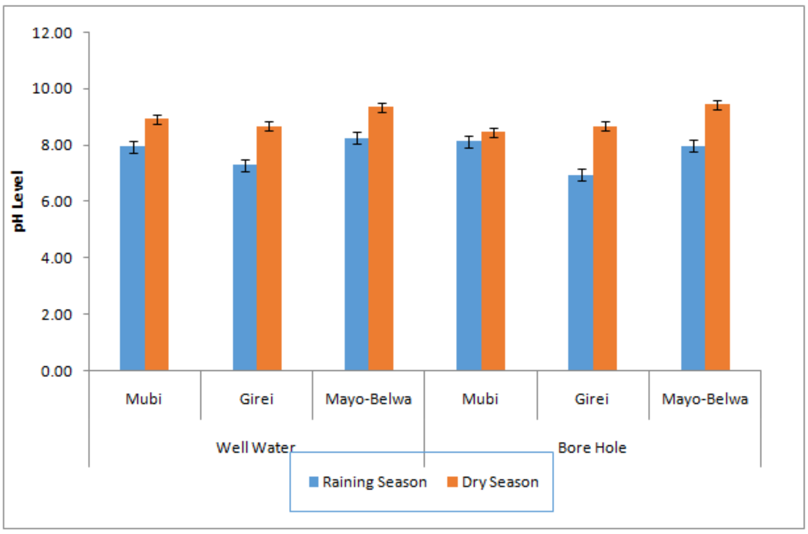


Figure 2. Mean pH values in Drinking Waters (Well & Borehole) in Mubi-North, Girei and Mayo-Belwa local government areas (Rainy & Dry Seasons)

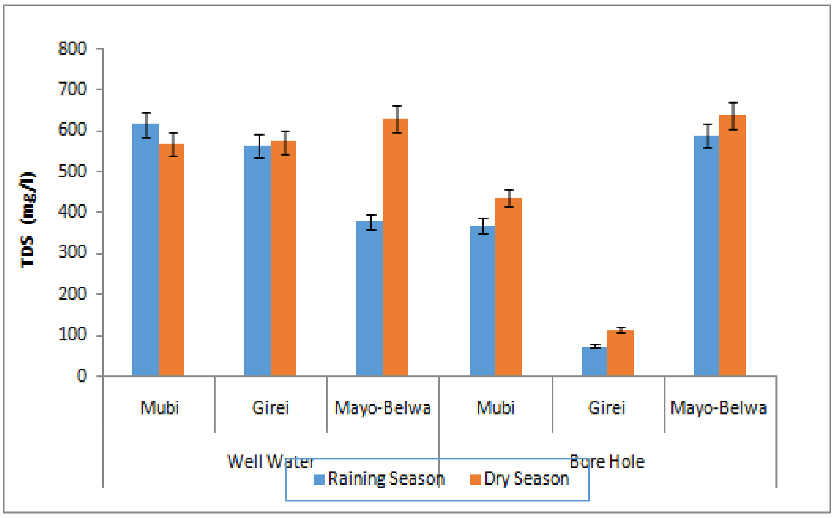


Figure 3. Mean TDS Values in Drinking Waters (Well & Borehole) in Mubi-North, Girei and Mayo-Belwa local government areas (Rainy & Dry Seasons)

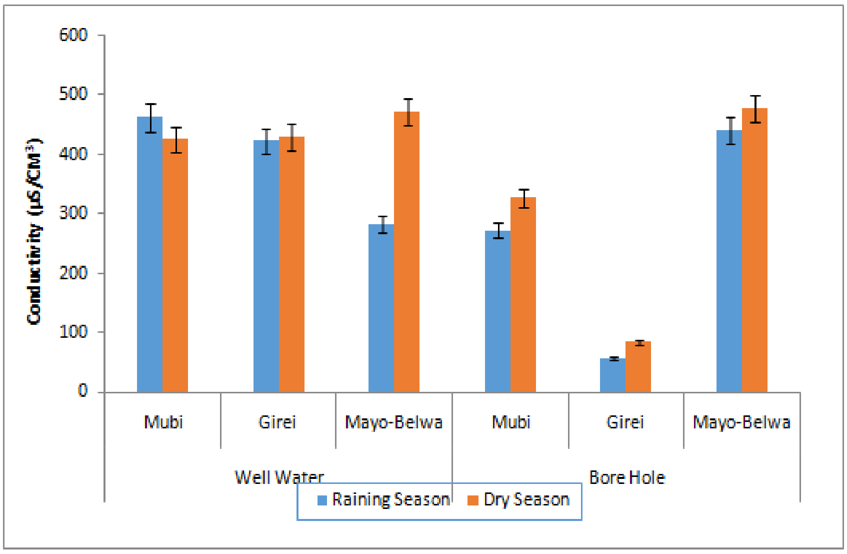


Figure 4. Mean Conductivity Values in Drinking Waters (Well & Borehole) in Mubi-North, Girei and Mayo-Belwa local government areas (Rainy & Dry Seasons)

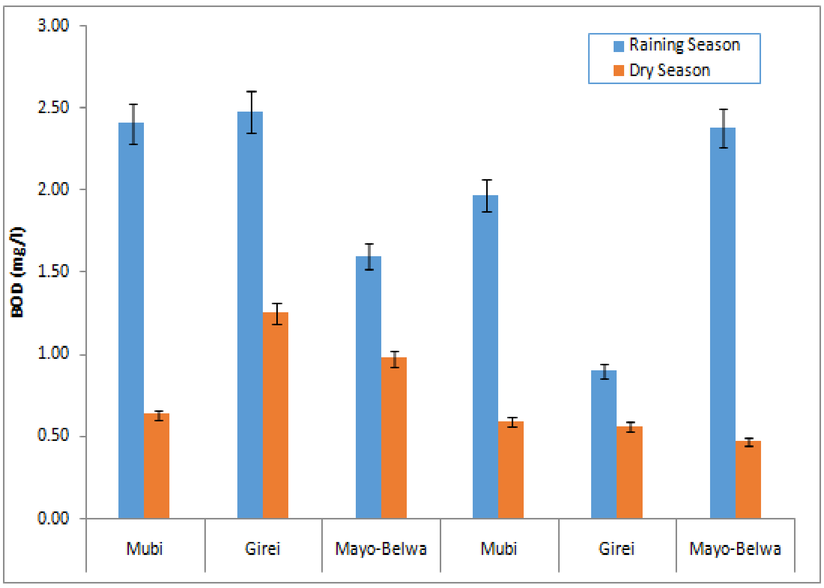


Figure 5. Mean BOD Values in Drinking Waters (Well & Borehole) in Mubi-North, Girei and Mayo-Belwa local government areas (Rainy & Dry Seasons)

Table 1. Correlation co-efficient (r) Matrix for the Mean Temperature Readings among Drinking Water from Well and Borehole in Mubi-North, Girei and Mayo-Belwa Local government areas of Adamawa State

	MWW (rainy)	MBH (rainy)	GWW (rainy)	GBH (rainy)	MBWW (rainy)	MBBH (rainy)	MWW (dry)	MBH (dry)	GWW (dry)	GBH (dry)	MBWW (dry)	MBBH (dry)
MWW (rainy)	1											
MBH (rainy)	.646	1										
GWW (rainy)	.715*	.661	1									
GBH (rainy)	.640	.820**	.518	1								
MBWW (rainy)	.834**	.556	.641	.807**	1							
MBBH (rainy)	.787*	.039	.647	.573	.786*	1						
MWW (dry)	-.713*	-.629	-.540	-.834**	-.796*	-.505	1					
MBH (dry)	-.779*	-.588	-.715*	-.668*	-.562	-.470	.835**	1				
GWW (dry)	-.586	-.542	-.467	-.578	-.090	-.016	.760*	.892**	1			
GBH (dry)	-.562	-.762	-.337	-.713	-.035	-.027	.428	.587	.962**	1		
MBWW (dry)	-.545	-.664	-.477	-.762*	-.827	-.025	.873**	.904**	.924**	.609	1	
MBBH (dry)	-.755*	-.237	-.471	-.463	-.742*	-.854**	.592	.800	.036	.551	.740	1

MWW: Mubi-North well water, MBH: Mubi-North Borehole,GWW: Girei well water, GBH: Girei Borehole; MBWW: Mayo-Belwa well water, MBBH: Mayo-Belwa borehole water
*= Significant correlation (r), at p<0.05 level (2-Tail)
**= Very Significant correlation (r), at p<0.01 level (2-Tail)
***= Highly Significant correlation (r), at p<0.001 level (2-Tail)

During dry season, the temperature reading in borehole water ranged from (30.39 – 33.19 ^oC). The least temperature value was recorded in Mubi-North local government area while the highest value was recorded in Mayo-Belwa local government area. All the temperature readings for borehole water during rainy and dry seasons across the sampled local government areas were within the permissible limit of 40.0 ^oC set by WHO. The analysis of variance of temperature readings for borehole water during rainy and dry season for the three local government areas showed significant difference at $p<0.05$. Figure 2 in respect to the local government area. The results showed that in well water during rainy season the mean pH values ranged from (7.3 – 8.24), the highest pH value was recorded in Mayo-Belwa, while the least value was recorded in Girei local government area. The recorded pH values in well water during rainy season across the three local government areas were within the tolerable limit of 6.50 – 8.50 set by WHO. The mean pH values recorded during dry season for well water across the sampled local government areas ranged from (8.68 – 9.36), the highest pH value was recorded in Mayo-Belwa while the least value was recorded in Girei local government area. All the pH values recorded in well water across the three local government areas during dry season exceeded the permissible limit of 6.50 – 8.50 set by WHO. The analysis of variance of pH values in well water during rainy and dry season for three local government areas showed significant difference at $p<0.05$.

The mean pH values for borehole water in the study area during rainy season ranged from (6.94 – 8.13), the highest mean pH value was recorded in Mubi-North local government area while least value was recorded in Girei local government area (Figure 2). Thus, all the recorded pH values in borehole water during rainy season across the three local government areas were within the tolerable limit of 6.50 – 8.50 set by WHO. Furthermore, the results on Figure 2 showed that during dry season, the pH values in borehole water ranged from (8.51 – 9.43) and the least mean pH value was recorded in Mubi-North local government area while the highest value was recorded in Mayo-Belwa local government area All the pH values recorded in borehole water across the three local government areas during dry season exceeded the permissible limit of 6.50 – 8.50 set by WHO. The analysis of variance of pH values in borehole water during rainy and dry season for three local government areas showed significant difference at $p<0.05$.

This agrees with range of pH values of (8.45 – 9.46) recorded by Incardona *et al.* (2013) in borehole water during dry season. Though, studies by Zhang et al. (2016) and Obia et al. (2015) recorded lesser pH value in both well and borehole water during rainy season. The higher pH value recorded in this study does not promptly poses danger of drinking the water as suggested by West (2018) that drinking water with a pH level above 8.5 only indicates that a high level of alkalinity minerals are present and does not pose a health risk, only that it can cause aesthetic problems, alkali taste to the water that makes coffee taste bitter; scale build-up in plumbing; and lowered efficiency of electric water heaters. Figure 3 presents the results on the mean TDS values for the respective well and borehole water during rainy and dry seasons across the Mubi-North, Girei and Mayo-Belwa local government areas of Adamawa state respectively. The results revealed that in well water during rainy season, the mean TDS values ranged from (377.67 – 617.00 PPM), the highest TDS value was recorded in Mubi-North local government area, while the least value was recorded in Mayo-Belwa local government area. However, the recorded TDS values in well water during rainy season across the three local government areas were within the tolerable limit of 1000 PPM set by WHO.

Also, the mean TDS values recorded during dry season for well water across the sampled local government areas ranged from (568.56 – 630.00 PPM), the highest TDS value was recorded in Mayo-Belwa, while the least value was recorded in Mubi-North local government area. All the TDS values recorded during dry season in well water across the three local government areas were within the permissible limit of 1000 PPM set by WHO. The analysis of variance of TDS values in well water during rainy and dry season for three local government areas showed significant difference at $p<0.05$. The mean TDS values for borehole water in the study area during rainy season ranged from (74.44 – 589.44 PPM), the highest mean TDS value was recorded in Mayo-Belwa local government area while least value was recorded in Girei local government area (Figure 4.3). Thus, all the recorded TDS values in borehole water during rainy season across the three local government areas were within the tolerable limit of 1000 PPM set by WHO. During dry season, the TDS values in borehole water ranged from (113.56 – 637.44 PPM), the least mean TDS value was recorded in Girei local government area while the highest value was recorded in Mayo-Belwa local government area.

All the TDS values recorded in borehole water across the three local government areas within the permissible limit of 1000 PPM set by WHO. The analysis of variance of TDS values in borehole water during rainy and dry season for three local government areas showed significant difference at $p<0.05$. The higher TDS value recorded during dry season which were significantly higher than those found in drinking water during rainy season ($p<0.05$) could be as results of reduction in water level which raised the concentration of TDS value in water. This agrees with earlier studies by Saiful et al. (2015), Anna et al. (2018), Ali et al. (2012) and Carreira et al. (2014), they all reported higher TDS values during dry seasons. Though, report by studies by Rusydi et al. (2015) and Marandi et al. (2013) could not established any significant difference in the TDS reordered in both rainy and dry season ($p>0.05$). Figure 4 presents the results on the mean conductivity values for the respective well and borehole water during rainy and dry seasons across the Mubi-North, Girei and Mayo-Belwa local government area of Adamawa state respectively. The results revealed that in well water during rainy season, the mean conductivity values ranged from (283.25 – 462.75 µS/cm^3), the highest conductivity value was recorded in Mubi-North local government area, while the least value was recorded in Mayo-Belwa local government area. However, the recorded conductivity values in well water during rainy season across the three local government areas were within the tolerable limit of 680 µS/cm^3 set by WHO.

Also, the mean conductivity values recorded during dry season for well water across the sampled local government areas ranged from (426.42 – 472.50 µS/cm^3), the highest conductivity value was recorded in Mayo-Belwa, while the least value was recorded in Mubi-North local government area. All the conductively values recorded during dry season in well water across the three local government areas were within the permissible limit of 680 µS/cm^3 set by WHO. The analysis of variance of conductivity values in well water during rainy and dry season for three local government areas showed significant difference at $p<0.05$. The mean conductivity values for borehole water in the study area during rainy season ranged from (55.83 – 478.08 µS/cm^3), the highest mean conductivity value was recorded in May-Belwa local government area while least value was recorded in Girei local government area (Figure 4.4). Thus, all the recorded conductivity values in borehole water during rainy season across the three local government areas were within the tolerable limit of 680 µS/cm^3 set by WHO. Likewise, during dry season the conductivity values in borehole water ranged from (85.17 – 442.08 µS/cm^3), the least mean conductivity value was recorded in Girei local government area while the highest value was recorded in Mayo-Belwa local government area. All the conductivity values recorded in borehole water across the three local government areas were within the permissible limit of 680 µS/cm^{3}set by WHO. The analysis of variance of conductivity values in borehole water during rainy and dry season for three local government areas showed significant difference at $p<0.05$. The current finding agrees with that by Thirumalini and Joseph (2013) and Siosemarde et al. (2013), who reported conductivity values 462.15 and 451.75 µS/cm^3 during dry season respectively, which was significantly higher than that in rainy season. Also, study by Odiba (2017) reported that the conductivity properties of Boreholes was significantly higher than that recorded in hand-dug wells from Bantaji and Rafin-kada settlements of Wukari L.G.A. Likewise, studies by McNeil and Cox (2012) attributed the higher conductivity value in dry season water to reduction in the water volume which increase the concentration of electrical conductivity in water. This concurs with the view held by Medeiros et al. (2018), Ali et al. (2012) and Marandi et al. (2013) they all expressed that reduction in water volume could account for higher conductivity. Though, study by Hayashi (2014) established that electrical conductivity in water is inversely related with the volume of water but directly related with water reduction rate. The results on the mean BOD values for the respective well and borehole water during rainy and dry seasons are presented in Figure 5 in respect to the local government area. The results revealed that in well water during rainy season, the mean BOD values ranged from (1.60 – 2.48 mg/l), the highest BOD value was recorded in Girie local government area, while the least value was recorded in Mayo-Belwa local government area. However, the recorded BOD values in well water during rainy season across the three local government areas were within the tolerable limit of 40 mg/l set by WHO. Also, the mean BOD values recorded during dry season for well water across the sampled local government areas ranged from (0.63 – 1.16 mg/l), the highest BOD value was recorded in Girei local government area, while the least value was recorded in Mubi-North local government area. All the BOD values recorded during dry season in well water across the three local government areas were within the permissible limit of 40 mg/l set by WHO. The analysis of variance of BOD values in well water during rainy and dry season for three local government areas showed significant difference at $p<0.05$.

The mean BOD values for borehole water in the study area during rainy season ranged from (0.90 – 2.39 mg/l), the highest mean BOD value was recorded in May-Belwa local government area while least value was recorded in Girei local government area (Figure 4.4). Thus, all the recorded BOD values in borehole water during rainy season across the three local government areas were within the tolerable limit of 40 mg/l set by WHO. Likewise, during dry season the BOD values in borehole water ranged from (0.47 – 0.59 mg/l), the least mean BOD value was recorded in Mayo-Belwa local government area while the highest value was recorded in Mubi-North local government area. All the BOD values recorded in borehole water across the three local government areas within the permissible limit of 40 mg/l set by WHO. The analysis of variance of BOD values in Borehole water during rainy and dry season for three local government areas showed significant difference at $p<0.05$. Salam and Salwan (2017) and Ranganna (2011) reported higher BOD value during dry season than rainy. Their studies attributed the higher BOD value to reduction in water volume which increases concentration of BOD in the remaining water. However, the current study recorded higher BOD values both in the well and borehole water during rainy season and this could be as results of leaching of residues from various agro-chemicals used during farming in the study area. Chirag (2017) and Idowu *et al.,* (2013) reported that region with more farming activities with indiscriminate use of chemical are likely to record more effluent in their soils and waters than other region. Also, Buntel (2015) recommended the conservative agricultural practices where organic manure and appropriate chemical will be used to prevent higher deposition of chemical in the drinking water. Wadie and Abduljalil (2010) argued that water with higher BOD is neither safe for drinking nor suitable for irrigation as higher concentration of BOD can accumulate leaves, stems and roots of the plants which make them unsafe for human consumption. Conclusively, this study has shown through its findings that the physical parameter for drinking water in the study area are generally within the threshold values stipulated by WHO but fluctuates seasonally (rainy and dry). Hence, both wells and boreholes are suitable for drinking, other domestic activities and healthy environment which promote primary productivity as at the time of this study.

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