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Water Quality Index for Drinking Water in Mubi-North, Girie and Mayo-Belwa Local Government Areas, Adamawa State, Nigeria

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Abstract : *The aim of this research is to develop a water quality index (WQI) of drinking water (wells and bore-holes) in the study areas i.e Mubi-north, Girei and Mayo-Belwa local government areas of Adamawa state, Nigeria based on physicochemical parameters. samples were collected in August-October for the rainy season and January-March for dry season. 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 for DO. Hanna portable pH/EC/TDS/temperature meter was used for pH conductivity, total dissolved solids and temperature at sample collection point . All data were collected, mean calculated and recorded at each of the sampling point. Phosphate and nitrate were determined using the HACH DR 2000 direct reading spectrophotometer method 8039. A simple arithmetic mean by using the three (3) equations below was adopted. QI =$\frac{(Mi-li)}{(Si-li)} X\ 100$,Wi= $\frac{k}{si}$ and WQI = ((Σwi n* qi n)/ Σ wi n). The results obtained in this research revealed that in rainy season, the well water in Mubi-North local government area recorded 53.21, while in Girei the well water recorded 54.82 and well water in Mayo-Belwa recorded 48.10. Thus, only well water from Mayo-Belwa has water quality index within the category of good water (26 – 50) as stated by WHO. During dry season, the well water in Mubi-North local recorded 41.09 while in Girei the well water recorded 48.69 and well water in Mayo-Belwa recorded 46.31. All sampled well water from three local government area have water quality index that fall within the category of good water (26 – 50) as stated by WHO. For borehole water, results showed that in rainy season, the borehole water in Mubi-North recorded 54.20 while in Girei the well water recorded 37.27andwellwaterin Mayo-Belwa 47.51. Conclusively, this study reveals that water quality index for drinking water in the study areas are generally within the threshold values stipulated by WHO but fluctuates seasonally (rainy and dry). Hence, calls for monitoring by the concerned agencies.*

Keywords: *water quality index, drinking water, seasonal variation,*

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I. Introduction

Water quality is determined by the chemical, physical and biological parameters of water. It is a measure of the state of the water with respect to the necessities of human needs or purposes (Abbasi and Abbasi, 2012). The water pollution of rivers requires great efforts, and water quality is an important issue in the field of water resources planning and management and requires data gathering, analysis, and interpretation (Yehia and Sabae, 2011). The Water Quality Index (WQI) is a simple method utilized as a part of surveying the general water quality using a group of parameters which reduce the large amounts of information to a single number, usually dimensionless, in a simple reproducible manner (Abbasi and Abbasi, 2012). It gives important data delineating the general water quality status which can be of extraordinary help in the choice of suitable water-treatment technique to address the issue of contamination. The primary WQI was suggested by Horton (1965) and subsequently other ideas were suggested as improvements to the original method. Numerous WQIs have been developed and approved around the world (Prasad and Kumari, 2008; Reza and Singh, 2010; Manoj et al., 2012; Dede, 2013), the differences between them being the statistical incorporation and translation of parameter values (Abbasi and Abbasi, 2012; Alobaidy et al., 2010; Lumb et al., 2011). The aim of this research is to develop water quality index (WQI) for drinking water (wells and bore-holes) in the study areas based on physicochemical parameters, to help the consumers to work towards proper management of water resources which will help in future water administration and protection arrangements.

II. Materials And Methods

Description of the study area

The study areas for this research covered the following local government areas in Adamawa state: Mubi-North, Girie and Mayo-Belwa, Adamawa state located at 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^Oeast of the Greenwich meridian (Sanusi, 2017 cited Adebayo, 1999). Composite sampling was adopted in all the study areas. In Mubi-North local government area, well1 is located at Shuwari Garden city on latitude N10^0.16.045' and longitude E13.16.716, well 2 is located at Sabon -layi 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 E13^0.16 623', bore-hole 2 at 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'

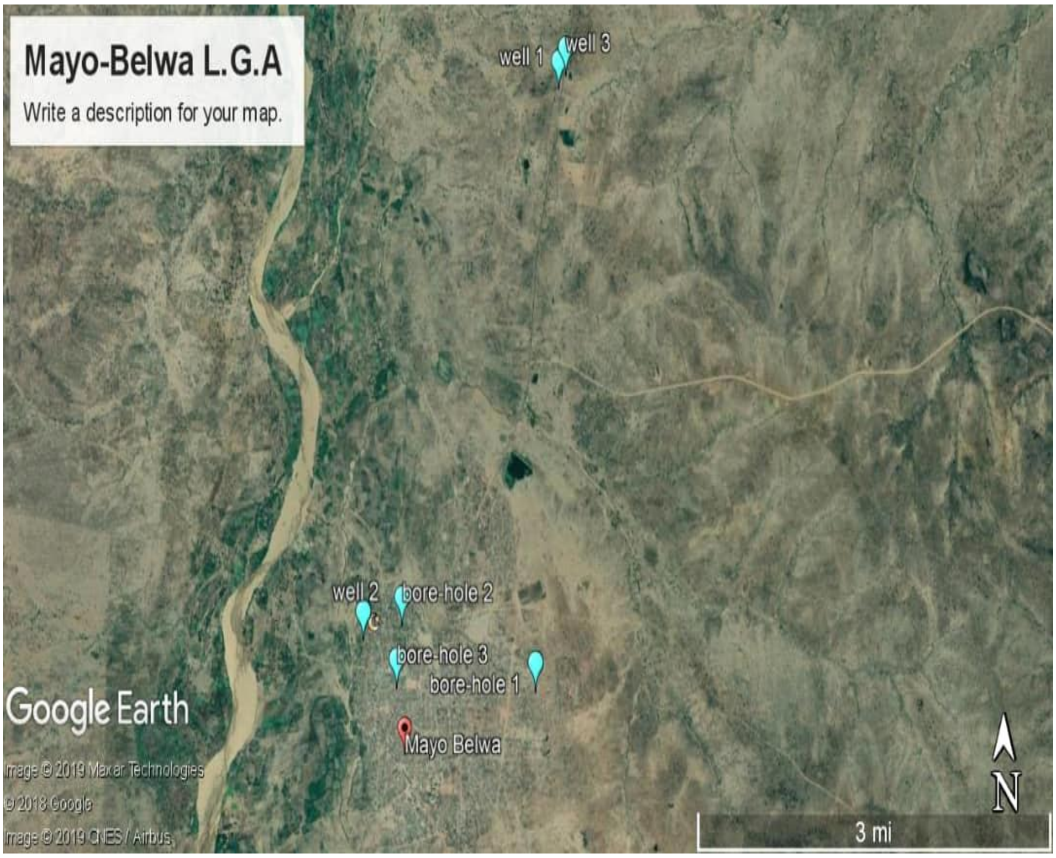
In Girie local government area, well 1 is located in Bajabure, Latitude N 9^0 18. 340' and longitude E12^0 27.859', well 2 is located Latitude 9^0 18.278 and longitude 12^0 27.859, well 3 is located on latitude N 9^0.18.161' and longitude E12^0 27.922', bore-water 1 is located Samunaka Bajabure on latitude N 9^0 18. 027' and longitude E 12^0.28.087', bore-hole 2is located on latitude N$9^0$18.152' and longitude E 12^0.27.885', bore-hole 3 is on latitude 9^0.18.32^{0}' and E$12^0$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 Sabon-layi on latitude N9^0.05.402' and longitude E12^0.04.436', bore-hole 2 at kofar fada on latitude N9^0 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.

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'


Mubi North Water Vendors
Write a description for your map
Legend
Feature 1
Government Guest House
Mosque
river site 1
Sabon Layi Bus Stop
Shuware Garden City
bore-hole point 2
well 2
Bore-hole point 1
well 3
bore-hole point 3
river site 1
river site 2
well 1
river site 3
Shuware Garden City
Google Earth
3000 ft
N


Bajabure,Girei L.G.A
showing sampling points
Legend
bore-hole 3
well 1
well 2
well 3
bore-hole 2
bore-hole 1
Google Earth
1000 ft
N



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. Phosphate was determined using the HACH DR 2000 direct reading spectrophotometer method 8048. The HACH phosver 3, phosphate powder pillow reagent was used in 25ml of the water sample against deionized water as blank at a wavelength of 890nm while nitrate was determined using the HACH DR 2000 direct reading spectrophotometer method 8039. The HACH nitraVer 5, nitrate pillow was used in 25ml of water sample against sample not treated with nitraVer 5 reagent as blank at a wavelength 0f 500nm.

Water Quality Index Determination

A simple arithmetic mean by using the three (3) equations below was adopted.

$$QI = \frac{(Mi-li)}{(Si-li)} X\ 100$$

$$Wi= \frac{k}{si}$$

WQI = ((Σwi n* qi n)/ Σ wi n).

Where Qi is the sub-index of the iTH parameter, Wi is the unit Weightage of the iTH parameter, n is the number of parameters included, Mi is the monitored values of the parameter Li is the deal value and Si is the standard value of the iTH parameter. The ideal value for PH= 7, dissolved oxygen = 14.6 mg/l, and for other parameters. It is equal to zero (Tripaty and Sahu 2005; Chowdhury *et al.*, 2012).

The weightage unit(WI) of each parameter was calculated a value inversely proportional to the standard of the world health organization (SI) world health organization, 2011.Based on the calculated WQI the category of water quality types is shown in below according to shweta *et al.,*, (2013).

This calculation produces a score between 0 and 100.The higher the score, the better the quality of water. The scores are then ranked into one of the five categories described below:

(I) Excellent: (WQI Value 0-25) - Water quality is protected with a virtual absence of impairment; conditions are very close to pristine levels. These index values can only be obtained if all measurements meet recommended guidelines virtually all of the time.
(II) Good: (WQI Value 26-50) - Water quality is protected with a slight presence of impairment; conditions are close to pristine levels.
(III) Poor: (WQI Value 51-75) - Water quality is almost always impaired; conditions usually depart from desirable levels.
(IV) Very poor (WQI Value 76-100) water quality is impaired; condition is not desirable.

(V) Unsuitable for drinking: WQI Value > 100

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.

Water quality index (WQI) for Drinking Water in the Study Area during Rainy and Dry Season

The results on Table 2 present the water quality index for well and borehole water during rainy and dry season periods in Mubi-North, Girei and Mayo-Belwa local government area respectively. The results showed that in rainy season, the well water in Mubi-North local government area recorded 53.21 WQI, while in Girei the well water recorded 54.82 WQI and well water in Mayo-Belwa recorded 48.10 WQI. Thus, only well water from Mayo-Belwa has water quality index within the category of good water (26 – 50) as stated by WHO. Also, during dry season, the well water in Mubi-North local government area recorded 41.09 WQI, while in Girei the well water recorded 48.69 WQI and well water in Mayo-Belwa recorded WQI of 46.31. All sampled well water from three local government area have water quality index, that fall within the category of good water (26 – 50) as stated by WHO.

Table 2 present further the water quality index for borehole water during rainy and dry season in Mubi-North, Girei and Mayo-Belwa local government area respectively. The results showed that in rainy season, the borehole water in Mubi-North local government area recorded 54.20 WQI, while in Girei the well water recorded 37.27 WQI and well water in

Table 2: Water Quality Index (WQI) for Drinking Water in Mubi-North, Girei and Mayo-Belwa Local government areas during Rainy and Dry Season

Source of water/session	Location	WQI	Remark
Well Water			
Rainy	Mubi-North	53.21	Poor
	Girei	54.82	Poor
	Mayo-Belwa	48.10	Good
Dry	Mubi-North	41.09	Good
	Girei	48.69	Good
	Mayo-Belwa	46.31	Good
Borehole Water			
Rainy	Mubi-North	54.20	Poor
	Girei	37.27	Good
	Mayo-Belwa	62.26	Poor
Dry	Mubi-North	42.82	Good
	Girei	38.53	Good
	Mayo-Belwa	47.51	Good

Mayo-Belwa recorded WQI of 62.26. Thus, only borehole water from Girei has water quality index fall within the category of good water (26 – 50) as stated by WHO. Also, during dry season, the well water in Mubi-North local government area recorded 42.82 WQI, while in Girei the well water recorded 38.53 WQI and well water in Mayo-Belwa recorded WQI of 47.51. All sampled borehole water from the three local government area have water quality index that fall within the category of good water (26 – 50) as stated by WHO (Figure 1).

The results on the water quality index for drinking water in the study area showed that well water in both Mubi-North and Girei local government areas were poor during rainy season expect in Mayo-Belwa where the value is good. Also, the water quality index for borehole water were general poor during rainy, especially in Mubi-North and Mayo-Belwa local government areas. This results point at possibility of inflow of residues and effluent into sources of drinking water in the study area during rainy season which further highlighted the possibility of residue from agrochemical product being eroded from farmland into well and borehole water. The good water index quality in dry season justified further the cutoff between farmland and the water sources in the three studied local government area, due to stoppage of erosion activities.

This agrees with the findings made by Ekwebelem (2013) Tiwari and Ali (2012), and Stigter et al.,, (2013) which recorded poor water quality index in, Abuaj, Nigeria, New Delhi, India and Portugal during wet season and good water quality index during dry season respectively. They attributed the difference to the decline water level, farming activities and indiscriminate discharge of effluent in their respective study area. Also, the reduction in water quality index value recorded in this study across the water sources during rainy season is an indication of various pollutants entering the waterways through different anthropogenic and natural factors like the release of untreated local sewage and spillover water from farming area.

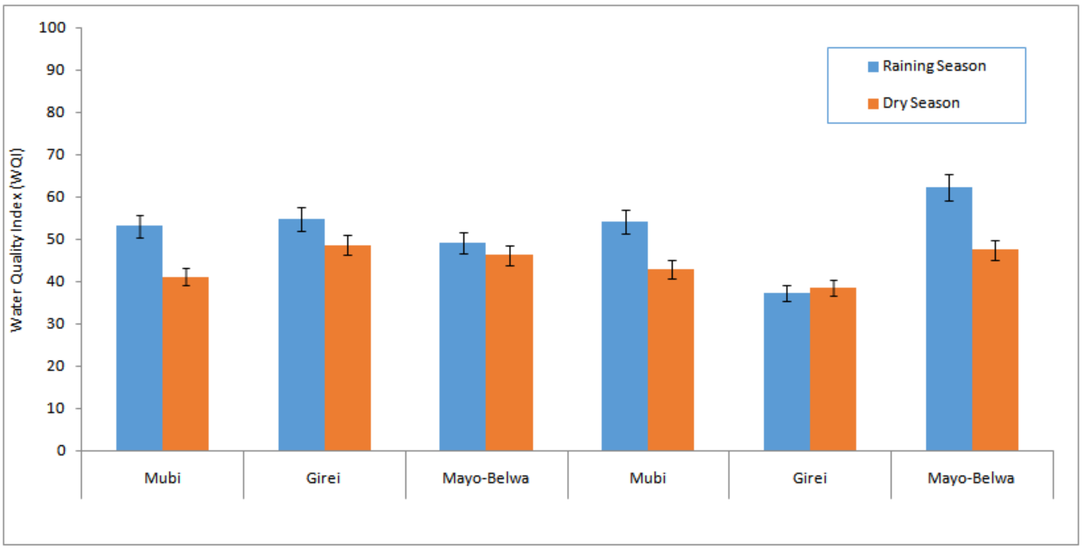


Figure 1: Summary of Water Quality Index (WQI) for Drinking Water (Well and Borehole) in Mubi-North, Girei and Mayo-Belwa local government area of Adamawa State

This agrees with the submission made by Al-Obaidy and Al-Khateeb (2013) that wastewater from horticultural areas account for low water quality index in Iran. Also, study by Pejman et al.,, (2014) found that the decrease in river water levels that promotes drainage from the ground water into the waterway during dry season accounted for improvement in water quality index significantly higher ($p<0.05$) than water quality index recorded during rainy season. The study by Makwe (2012) accounted that causes for low water quality index during rainy season is simply through different inflow of impure water from different sources into drinking water. According to respective conclusion drawn from studies by Shingo (2012),Parihar et al.,, (2012), Ranjana (2013), and Patil and Patil (2014), there are always large yearly fluctuations in the level of river water level during dry and rainy season which accounted for variation in the water quality index. Thus, it is a common experiences during rainy season that there should be inflow of water from different reservoirs full of organic materials, plankton, a local government area and plants with dark green color, reducing in pH and oxygen, raising turbidity, total dissolved solids and affecting the overall water quality. Etim et al., (2012) indicated that in the Niger delta in Nigeria, most water sources have low water quality index and their water are unsafe for consumption. Similar result was reported by Etim et al., (2013) in Akwa-Ibom, where most water during rainy season are poor for human consumption.

III. Conclusion

Water resources are of major environmental, social and economic value to human and if water quality becomes degraded this resource will lose its value. The healthy society for man, animals and plants is largely depends on the quality of water available. The failure of public treated tap water system supply and the sensitization of the dangers associated with drinking poor quality water have led many communities drinking stream or rivers water as well as sources of water like deep-wells and boreholes respectively. However, the current study has shown that both the wells and boreholes water are not totally safe from effluents, residues and wastes emanating from human, industrial and economic activities.

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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