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Assessment of Boreholes Water Quality in Bali Local Government, Taraba State, Nigeria

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Abstract

The study assesses borehole water quality from the 22 wards of Bali Local Government. This was aimed at evaluating the portability of the water for human consumption and analysis of the spatio-temporal variation of borehole water quality in Bali Local Government Area. A total of 22 water samples were collected from boreholes during the dry and rainy seasons, the physical and chemical analysis of the water samples were carried out using a Palintest Photometre 5000 following the guideline as contained in the instruction manual. The result of the analysis reveals that Turbidity with an average value of 17.10mg/L, Fluoride (1.74mg/L), Chlorine (107.80mg/L), Ammonia (21.89mg/L) and copper (10.33mg/L) are above the WHO and SON standards. The implications of ingestion of these contaminants include Gastro-Intestinal distress, liver or kidney damage and other health implications. Based on these findings, it is recommended that Public health institutions should intensify the awareness and enlightenment to water users on home based water treatment techniques.

Keywords: Groundwater, Mean Value Test, Water Quality, SON, WHO Standard

INTRODUCTION

Water is one of the most important and critical resource that supports life. The amount and quality of water provided affects the functioning of the human system. Thus water constitutes 75% of body weight. In view of the importance of this resource to human well-being and survival; and the basic concern for sustainable water resource management, it is pertinent to manage the finite resource with a view of providing water at the right quantity and the right quality.

Water quality is the physical, chemical and biological state of water in relation to its uses. Water quality should be assessed on the characteristics of the water relative to the beneficial uses of the water (Lee, 1999). Evaluation of these qualities is mainly to compare the concentration of key elements with the standards set by the World health Organization and other Sister Organizations to ascertain the portability/safety of the water, for human consumption.

Compared to pipe borne water, boreholes are more susceptible to contamination (Tole, 1997; Ojelabi *et al.*, 2001). This is particularly widespread and acute in the developing world where unchecked industrial growth, lack of monitoring facilities and failure to enforce or absences of environmental regulations exacerbated the situation (Oluwande *et al.*, 1983; Ntengwe, 2005). The presence of contaminants that deviate from the acceptable World Health Organisation (WHO) guideline values has been associated with the occurrence of different kinds of disease such as typhoid fever, dysenteries, gastrointestinal and infectious hepatitis (Hammer, 1996; Jiang, 2011). This makes it imperative to monitor levels of chemical contaminant in boreholes. The escalation of human population and expansion in urban land use are some of the major factors that are responsible for increased demand for water and as a response to these escalated demand alternative water sources such as groundwater are exploited through massive drilling of boreholes as witnessed in the study area.

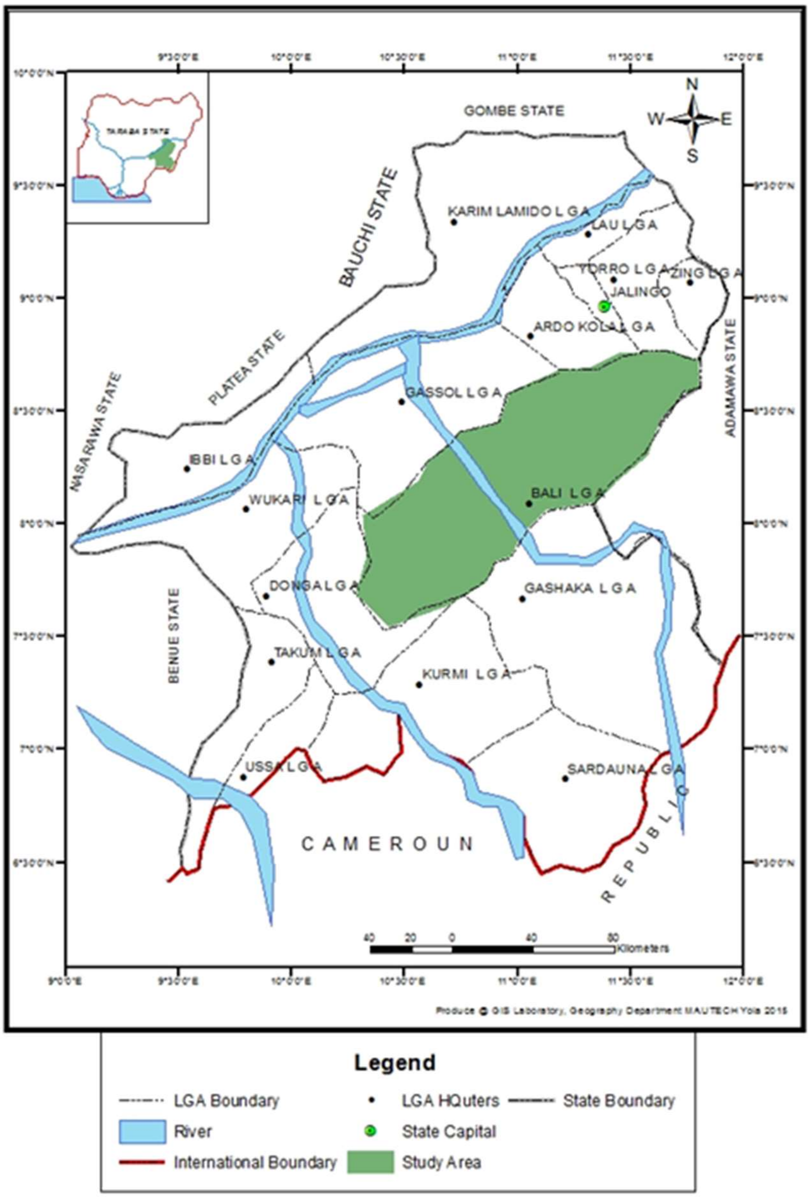

FIGURE 1 TARABA STATE SHOWING THE STUDY AREA

The main theme of this paper is the analysis of the physical and chemical characteristics of water within Bali Local Government Area. Bali, is a semi urban town, as such it has a considerably large and growing population, a mixture of urban and typical rural land use, these factors together with the local geology significantly affects the pattern of water demand and its quality. The major objectives of the paper are to:

(i) Evaluate the chemical concentration of elements in borehole water samples in Bali Local Government Area.
(ii) Compare the concentration of elements with the Standard Organisation of Nigeria and the World Health Organisation Standard for drinking water.

(iii)Recommend measures aimed at safeguarding water quality and providing portable drinking water in Bali Local Government Area.

MATERIALS AND METHOD

Bali local government area (LGA) is one of the 16 local government areas in Taraba State, Nigeria. (figure 1) it covers a total land area of about 9,146km^2 and extends between latitude 7^{o}30′00″ to 8^{o}10′00″ North of the equator and 5^{o}45′00″ to 6^{o}15′00″ East of the Greenwich meridian (Taraba State Government 2005). It share common boundaries with Ardo Kola and Gossol local government in the North, Donga and Kurmi in the West and Gashaka local government form the South. It also share border with Adamawa State in the North - East boarder.

The area is generally situated on the banks of the upper course of Taraba River at some 150km from Jalingo, by virtue of its location in the water shed area of the river Benue and it approximity to Taraba River a major tributary of river Benue at an altitude of 450m above sellur. The temperature region is warm to hot throughout the year with a slight cool period between November February, temperature ranges between 23-40^{o}C. There is a gradual increase in temperature from January to April which also increases the demand of water for domestic uses in the area.

Bali is an important economic centre because of its food crops market which is well linked with other part of the state and country at large. The population of the local government is 208,935 (NPC 2006). Closely associated to the population is varied land uses which are associated with the semi-urban status of the area and various urban land uses which generate a high demand of water resources. The water supply situation in the area is mainly characterized by scarcity especially in the dry season, most of the households do not have access to pipe borne water as such they rely on bore holes, hand dug wells and water vendors for their daily water supply.

Water Sampling and Analysis

Water samples were collected from randomly selected boreholes. A borehole is selected from each of the 22 districts within Bali local government area. Water samples were collected from each borehole twice. The first set of samples were collected in May corresponding with the rainy season and the second set in November corresponding with the dry season. In total 44 water samples were collected for the study. The borehole water sample were collected in prewashed (with detergent, diluted NO_3 and doubly de-ionized distilled water, respectively) polyethylene bottles. The determination of the physical and chemical properties of the water sample were performed on the same day sample were taken. This was done at the United Nations Children's Fund (UNICEF) assisted Rural Water Supply and Environmental Sanitation Agency. Analytical water test tablets (photometre grade) reagents for specific test were used for the preparation of all solutions. Water samples from the boreholes were analysed using a palintest photometre 5000 following the procedures set out in the instruction booked (Palintest, 1980). Each sample was analysed for total dissolved solids (TDS) Nitrate (NO^3) Fluoride (F), Chlorine ($C1^-$), Iron (Fe^{2+}), Ammonia ($P0_4^{3-}$), Hardness ($CaCo^3$) Sulphate (SO_4^2) Manganese (Mn^2) Copper (CU), Magnesium (mg^{2+}) Calcium (Ca^{2+}), total alkalinity and total salinity.

The concentrations of elements present were compared with the World Health Organization (WHO) (World Health Organization ,2011) and the Standard Organization of Nigeria (SON) (Standard Organisation of Nigeria, 2007) guidelines values to evaluate the portability of the water for human consumption. Mean Value test was used in carrying out the comparison. The Mean Value test is based on the estimation of the 95% upper confidence limits of the mean concentration of a contaminant (95% UCL, also referred to as US_{95}) and its use as the appropriate value to be compared with the relevant guideline value or site specific assessment criterion. This 95% UCL is meant to provide a reasonably conservative estimate of whether the measured concentration is acceptable, considering the uncertainty and variably associated with site investigations.

The necessary calculation involves five steps (Dean, 2007) as follows:

(i) Calculate the arithmetic sample mean x
(ii) Calculate the unbiased sample standard deviations
(iii) Select an appropriate t value e.g. 95^{th} percentile confidence limit, t the tabulated "t value" can be obtained from our figure mathematic table.
(iv) Calculate the upper 95^{th} percentile bound of sample as $US_{95} = x + (ts\sqrt{n})$
(v) Compare the upper bound value (US_{95}) with the guideline value G.

RESULTS

The results of the borehole water analysis for samples collected in the rainy and dry seasons are presented in tables a and b – the concentration of each parameter varies from one sample point to the other. This is then compared to the SON and WHO acceptable values to determine and compare the suitability and effect of continual consumption of such waters.

Water quality evaluation: Parameters within guideline levels

The results showed that all of the boreholes tested were well within the limits prescribed by SON and WHO both in the wet and dry seasons for electrical conductivity (EC), temperature, total dissolved solids (TDS), Nitrate (No_3^-), total hardness ($CaCo_3$) Sulphate ($S0_4^{2+}$), Copper (Cu), Magnesium (Mgt) and Calcium (Ca^{2+}). Conductivity ranged between 118-5sl/cm in Letere to 416 sl/cm in Tiba. Temperature ranged between 23.0^{o}c in Budowa n the rainy season to 45.0oc in Letere in the dry season. Total dissolve solid ranged between 52.6ppm in Dakka and 528ppm in Letere. Nitrate range between from 0.3mg\L in Gilari to 62mgl in Letere. Total harness varied from 22mg\L in Sidale and Kusum in the dry season to 200mg\L in Letere in the rainy season. Sulphate varied between 3.0mg\L in Nainawa to 250mg\L in Letere. Copper ranged between 0.04mg\L Shema to 42mg\L in Jakalafiya and G/Dole. At these levels, there parameters do not rose any health impact and are within the SON and WHO guide line values. As such it will be sufficient to conclude that these parameters are unlikely to be sources of water contamination in Bali local government of Taraba state North Eastern Nigeria. On the other hand, there were incidences in which Turbidity, Ph, Fluoride, Chlorine, Iron and Manganese are outside guideline values.

Water Quality Evaluation: Parameter Outside guideline Levels

Turbidity

In this study, eleven out of the 22 samples had turbidity values outside the SON and WHO guideline value of 5 NTU in the rainy season, turbidity value ranged between 0.26 NTU in Nainawa to 125 NTU in Letere. The concentration was generally less in the dry season with all the boreholes having turbidity values below the SON and WHO guide line levels. The source of high turbidity in Letere is most likely due to those generated as water mores through the loose soils of the area into the ground water supply. The average concentration of turbidity in the rainy season when there is high likelihood of mud and silt been washed into underground water will suggest the need to constantly measure this parameter especially in the rainy season.

pH

PH is a measure of hydrogen ion (H+) and negative hydroxide ian (OH-) in water. It indicate whether the water is acidic or alkaline (World Health Organization, 2006). In pure water, the concentration of positive hydrogen lons is in equilibrium with the concentration of negative hydroxide ions and the pH measures exactly 7 on a PH scale ranging from 1 – 14 the SON and WHO set a PH guideline value of between 6.5 and 8.5 as generally considered satisfactory for drinking water. The pH of borehole water of our study area was generally within the guideline value except in Letere where pH value was 5.2. The highest pH value of 8.5 was recorded in Suntai, Takalafiya, Mayo Kam, G/Dole and Kusum. pH is generally considered to have no direct impact of humans. However, long-term intake of acidic water can invariably lead to mineral deficiencies (Fairweather – Tait and Hurrel, 1996). Because virtually all ground water comes from precipitation that socks into the soil and passes down to the aquifers high pH is widespread could also be an indication of acidic rains in the area.

Fluoride

The concentration of fluoride in Unguwan Landa, B/Jala, Suntai, Letere and Shema areas both in the rainy and dry season when concentration was up to 2.0, 2.1, 2.5, 4.1 and 2.5mg\L deviate from 1.5mg/L suggested as guideline value by SON and WHO in the study area, fluoride concentrations ranged between 0.002mg/L in Ganlari to 4.1mg/L in Letere high concentration of fluoride containment in ground water tend to be found in association with crystalline rocks containing fluorine-rich minerals, especially granite and volcanic rocks, shallow aquifers in arid areas experiencing strong evaporation, sedimentary aquifers undergoing ion exchange and inputs of geothermal water. Fluoride has long been found to have a beneficial effect on dental health as such it is an additive in toothpastes and food. However, when present in drinking water at concentrations much above the guideline value of 1.5mg/L, long term use can result in development o f dental fluorisis or at its worst cripping skeletal fluorisis. Although, the incidence of fluoride concentration outside guideline value in our study is found in five villages. It is important for water managers to constantly monitor this parameter as others studies in the region have also revealed high concentration of water samples showing high F concentrations (Waziri, *et al.,* 2012).

Chlorine

The use of chlorine in drinking water as a disinfectant has played a critical role in the prevention of water borne diseases. According to the (World Health Organisation 1993) the adoption of drinking water chlorination has been one of the most significant advances in public health protection. However, when concentration of chlorine in water is above the guideline value of 5mg/L, it could result in irritation of the oesophagus, a burning sensation in the mouth and throat, and spontaneous vomiting. It has also been suggested that episodes of Dermatitis, Asthma, Rectal cancers can be triggered by exposure to chlorinated water (Watson and Kibler, 1933; Eun *et al,* 1984). Almost all the samples are having a concentration above the SON and WHO standards on Tables 1 and 2 below

Table 1: Chemical and Physical characteristics of water samples from districts of Bali Local Government Area in the Rainy Season

Parameters	S/Dale	Abujan Bali	Nainawa	Banawasa	U/Ladan	B/Jalo	Suntai	Maigoge	Takalafiya	Jatau	G/Chede	Budowa	Pangi	M/Kam	P/Manga	Letere	Tiba	Dakka	G/Lari	Shema	G/Dole	Kasum
Turbidity (NTU)	0.52	**11.70**	0.26	1.39	**8.57**	3.4	4.50	2.15	3.8	**46**	**25**	**30**	**45**	4.0	2.15	**125**	**25**	**62**	**7.14**	**8.57**	3.8	4.0
Conductivity (ohms/cm)	148.7	119.9	473	122.5	173	150	180	315	313	218	385	514	420	319	316	1185	416	196.4	203.1	173	313	319
Temperature (°C)	30°	30.1	29.4	29.5	29.5	29.6	26	24	27	25	26	23	28	28	28	45	25	29	28	29.5	27	28
PH	6.71	6.71	6.71	6.71	6.70	6.71	8.5	6.5	8.5	6.2	6.5	6.5	6.5	8.5	6.5	5.2	6.5	6.5	6.5	6.70	8.5	8.5
TS (PPM)	74.6	55.8	237	57.7	86.5	75	76	162	108	110	180	205	210	150	150	528	225	52.6	115	86.5	108	150
Nitrate (N03) mg/l	18	28.0	18	10	35	16	15	4.0	25	18	25	28	20	35	42	**62**	18	16.2	0.3	35	25	35
Fluoride (f) mg/l	1.5	1.4	1.2	0.5	**2.5**	**2.1**	**2.0**	1.2	0.5	0.8	0.8	0.5	0.3	1.5	1.5	**4.1**	1.5	0.32	0.002	**2.5**	0.5	1.5
Chlorine (Cl) mg/l	**150**	**195**	**45**	**52**	**135**	**54**	**45**	**25**	**54**	**40**	**120**	**185**	**26**	**85**	**200**	**5.3**	**62**	0.15	**15**	**135**	**54**	**85**
Iron (Fe^{2+}) mg/l	0.03	0.01	0.1	0.1	0.2	0.2	0.01	0.02	0.4	0.02	0.03	0.02	0.01	0.01	0.001	**0.4**	0.03	0.04	0.06	0.2	**0.4**	0.01
Ammonia (P04) mg/l	**15**	**28**	**35**	0.5	**16**	**14**	**1.5**	**1.5**	**18**	**15**	**22**	**28**	**26**	**30**	**29**	**0.6**	**0.6**	**24**	**08**	**16**	**18**	**30**
Hardness (CaC03) mg/l	54	52	67	72	32	65	50	35	64	85	65	85	64	62	85	200	120	64	63	32	64	62
Sulphate (S04) mg/l	165	65	3.0	81	85	6.0	6.0	4.0	42	54	21	120	25	82	125	250	120	130	48	85	42	82
Manganese (Mn^{2+}) mg/l	0.02	0.2	0.2	0.2	0.3	0.2	0.1	0.1	0.03	0.04	0.01	0.2	0.02	0.02	0.006	0.03	0.06	0.08	0.07	0.3	0.03	0.02
Copper (cu) mg/l	**43**	**33.0**	0.5	**4.2**	0.4	0.04	**3.2**	**4.3**	**2.5**	**2.02**	**2.5**	**3.0**	**2.6**	**3.5**	2.0	**2.5**	**2.5**	**2.5**	**2.5**	0.4	**2.5**	**3.5**
Magnesium (mg) mg/l	0.18	0.5	2.0	2.0	0.02	3.01	2.0	2.0	0.3	0.2	0.3	0.2	0.3	0.3	0.3	0.2	3.01	0.3	0.2	0.02	0.3	0.3
Calcium (ca) mg/l	2.0	0.2	4.5	0.3	0.04	4.5	2.0	3.0	42	35	22	35	25	15	15	25	4.5	35	22	0.04	42	15
Total Alkalinity mg/l	2.2	2.5	2.2	0.3	4.0	3.5	3.4	3.0	6.5	7.8	4.5	3.0	4.6	2.5	3.0	4.5	0.3	6.5	4.0	4.0	6.5	2.5
Total Salinity	0.5	4.2	2.1	4.1	4.2	3.02	1.5	4.5	3.5	5.8	6.02	25	3.5	15	5.2	2.5	4.2	4.5	5.8	4.2	3.5	15

Sources: Field work (July-October, 2015)

NOTE: Bold values indicate incidences where parameters are outside guideline value

Table 2: Chemical and Physical characteristics of water samples from districts of Bali Local Government Area in dry Season

Parameters	S/Dale	Abujan Bali	Nainawa	Banawasa	U/Ladan	B/Jalo	Suntai	Maigoge	Takalafiya	Jatau	G/Chede	Budowa	Pangi	M/Kam	P/Manga	Letere	Tiba	Dakka	G/Lari	Shema	G/Dole	Kusum
Turbidity (NTU)	0.1	**4.1**	1.2	1.3	**0.1**	1.3	0.4	2.1	0.4	**3.0**	**0.3**	**1.0**	**3.0**	2.0	0.2	**1.2**	**2.1**	**2.2**	**0.4**	**2.2**	1.2	2.0
Conductivity (ohms/cm)	148.7	11.9	473	122.5	173	150	180	315	313	218	385	514	420	319	316	118.5	416	196.4	203.1	173	313	319
Temperature (°C)	35	32	39	39.5	35	33	36	34	37	38	39	39	38	38	35	45	32	29	38	35	37	38
PH	6.71	6.71	6.71	6.71	6.7	6.71	8.5	6.5	8.5	6.2	6.5	6.5	6.5	8.5	6.5	5.2	6.5	6.5	6.5	6.7	8.5	8.5
TS (PPM)	74.6	55.8	237	57.7	86.5	75	76	162	108	110	180	205	210	150	150	528	225	52.6	115	86.5	108	150
Nitrate (N03) mg/l	18	28	18	10	35	16	15	4	25	18	25	28	20	35	42	**62**	18	16.2	0.3	35	25	35
Fluoride (f) mg/l	1.5	1.4	1.2	0.5	**2.5**	**2.1**	**2**	1.2	0.5	0.8	0.8	0.5	0.8	1.5	1.5	**4.1**	1.5	0.32	0.002	**2.5**	0.5	1.5
Chlorine (Cl) mg/l	**150**	**195**	**45**	**52**	**135**	**54**	**45**	**25**	**54**	**40**	**120**	**185**	**26**	**85**	**200**	**5.3**	**62**	0.15	**15**	**135**	**54**	**85**
Iron (Fe^{2+}) mg/l	0.03	0.01	0.1	0.1	0.2	0.2	0.01	0.02	0.4	0.02	0.03	0.02	0.01	0.01	0.001	**0.04**	0.03	0.04	0.06	0.2	**0.4**	0.01
Ammonia (P04) mg/l	**15**	**28**	**35**	0.5	**16**	**14**	**1.5**	**1.5**	**18**	**15**	**22**	**28**	**26**	**30**	**29**	**0.6**	**0.6**	**24**	**0.8**	**16**	**18**	**30**
Hardness (CaC03) mg/l	24	22	37	42	32	45	25	35	24	35	35	45	34	32	45	80	55	34	23	32	34	22
Sulphate (S04) mg/l	165	65	3	81	85	6	6	4	42	54	21	120	25	22	125	250	120	130	48	85	42	82
Manganese (Mn^{2+}) mg/l	0.02	0.2	0.2	0.2	0.3	0.2	0.1	0.1	0.03	0.04	0.01	0.2	0.02	0.02	0.006	0.03	0.06	0.08	0.07	0.3	0.03	0.02
Copper (cu) mg/l	**43**	**33**	0.5	**4.2**	0.4	0.04	**3.2**	**4.3**	**2.5**	**2.02**	**2.5**	**3**	**2.6**	**3.5**	2	**2.5**	**2.5**	**2.5**	**2.5**	0.4	**2.5**	**3.5**
Magnesium (mg) mg/l	0.18	0.5	2	2	0.02	3.01	2	0.2	0.3	0.2	0.3	0.2	0.3	0.3	0.3	0.2	3.01	0.3	0.2	0.02	0.3	0.3
Calcium (ca) mg/l	2	0.2	4.5	0.3	0.04	4.5	2	3	42	35	22	35	25	15	15	25	4.5	35	22	0.04	42	15
Total Alkalinity mg/l	2.2	2.5	2.2	0.3	4	3.5	3.4	3	6.5	7.8	4.5	3	4.6	2.5	3	4.5	0.3	6.5	4	4	6.5	2.5
Total Salinity	0.5	4.2	2.1	4.1	4.2	3.02	1.5	4.5	3.5	5.8	6.02	25	3.5	15	5.2	2.5	4.2	4.5	5.8	4.2	4.5	15

Field work (January-May, 2015)

NOTE: Bold values indicate incidences where parameters are outside guideline value

Iron

Similar to turbidity, the concentration of iron was generally found to be within guideline value of 0.3mg/L in both rainy and dry seasons except only in four districts was well outside the guideline value. These districts are Takalafiya (0.4mg/L), Letere (0.4mg/L), Gamdole (0.4mg/L). Iron concentration range between 0.07 and 0.04mg/L in both seasons. Mean concentration in the rainy season and dry season is the same as 0.1mg/L.

It has been suggested that high rainfall is essential in increasing iron concentration in boreholes (Abubakar and Adekola, 2012). Rain water as it infiltrates the soil and underlying geologic formations dissolves iron, causing it to sink into aquifers that serve as sources of ground water for borehole. Therefore, it is not surprising that iron concentration is high in all the seasons.

Ammonia

Concentration of ammonia in the water samples ranges from 0.05 to 35mg/L with an average value of 17.1mg/L both in the dry and rainy seasons. The values of Ammonia in both rainy and dry seasons are all above the 0.5mg/L guideline value except in Banawasa which has 0.5mg/L. Ammonia can occur naturally in ground water, while in the environment, ammonia originates from metabolic agricultural activities especially from the intensive rearing of farm animals. Ammonia in water is an indicator of possible bacterial sewage and animals waste pollution. The level of Ammonia could favour bacteriological contamination of the water.

Manganese

Manganese occurs naturally in groundwater sources and in soils. However, human activities such as automobile emission are also responsible for manganese concentrations in the environment (Lovangor *et al*., 1996). In this study, concentration of Manganese is well within WHO standard but the level in Unguwan Ladan and Shema (0.3mg/L) is outside permissible level for manganese under the SON standard of 0.2mg/L, but within the WHO standard of 0.4mg/L

Water quality across the Wards in Bali Local Government

All the wards in Bali local government area have at least two or more incidence of water contamination. This is not helped by the fact that all of the boreholes have levels of turbidity outside guidelines values in the rainy season. The result shows that water samples from Nainawa and Banawasa wards are of the best quality with only one parameter each falling outside the guideline value, Chlorine for both the two wards and Ammonia for Nainawa and Copper in Banawasa in the rainy season. Letere appear to have the worst water quality indicators with eight parameters - Turbidity, Temperatures Nitrate, fluoride, chlorine, iron, Ammonia and Copper. Falling outside guideline value in the rainy season. Water quality improve in the dry season with Four wards (Nainawa, Banawasa, P/Manga and Dakka) are having only two parameters of water contaminants only.

Comparison of Concentration of Elements in the Samples with SON and WHO Standards

The mean value test provides an overall assessment of water quality in the study area. The mean value test result presented on table 3, shows that concentration of Turbidity, Fluoride, Chlorine and Copper are above either The World Health Organization (WHO) or Standard Organization of Nigeria (SON) Standards. The health Implication of high concentration of these element is varied ranging from provision of nuclei for attachment and growth of pathogenic microorganism (as a result of high turbidity), debilitating skeletal and dental fluorisis (as a result of high Fluoride Concentration) and objectionable taste (as a result of high concentration of Copper and Chlorine).

Table 3: Mean value test of water samples

Parameters	Upper Bound Values			SON	WHO
	Rainy season	Dry season	Average		
Turbidity (NTU)	**32.26**	1.93	**17.10**	5	
Conductivity (Ω/cm)	321.83	320.76	321.29	1000	2500
Temperature (°C)	30.27	37.92	34.09	23 - 40	23 - 40
pH	7.35	7.35	7.35	6.5 - 8.5	6.5 - 8.5
TDS (PPM)	189.22	191.11	190.17	500	1000
Nitrate ($N0_3$) (mg/L)	30.00	30.00	30.00	50	50
Fluoride (F) (mg/L)	**1.74**	**1.74**	**1.74**	1.5	
Chlorine (Cl) (mg/L)	**107.80**	**107.80**	**107.80**		5
Iron (Fe^{2+}) (mg/L)	0.17	0.14	0.16		0.3
Ammonia ($PO4^{3-}$) (mg/L)	**21.89**	**21.89**	**21.89**		0.5
Hardness ($CaC0_3$) (mg/L)	85.56	41.81	63.69	150	500
Sulphate ($SO4^{2-}$) (mg/L)	99.20	99.20	99.20	100	250
Manganese ($Mn^{2+)}$ (mg/L)	0.13	0.14	0.14	0.2	0.4
Copper (Cu) (mg/L)	**10.33**	**10.33**	**10.33**	1	2
Magnesium (mg^{2+}) (mg/L)	1.36	1.16	1.26		100
Calcium (Ca^{2+}) (mg/L)	22.46	22.46	22.46		150
Total Alkaline (mg/L)	9.53	4.54	7.04		
Total salinity (mg/L)	8.28	8.32	8.30		

Bold values indicate incidences where parameters are outside guideline value

DISCUSSION

Water quality assessment is one of the key aspects of water resources management. The result of this study, suggest that assessment samples from Bali Local Government Area against the SON and WHO show that ground water supply in the study area is of poor quality. Concentration of Fluoride, Ammonia, Chloride and Copper have upper bound value (US_{95}) above the guide line values as such this calls for serious health concern. In the past, similar studies carried out in the North East Region by Adekola *et, al.,* 2015, found borehole water from Gassol local government area to have levels of Turbidity (NTU), Chlorine (Cl) and Iron (Fe^{2+}) which are the major sources of borehole water contamination in the study area. In that study the upper bound value (US_{95}) of PH was found to be above the guideline value.

CONCLUSION AND RECOMMENDATIONS

The unprecedented growth in population and the climatic stress responsible for erratic rainfall have combined to limit the availability of surface water resources within the entire North Eastern Region. Acute water scarcity especially in dry season has forced majority of the population to rely on ground water supplies, hence the presence of these contaminants in high concentration in borehole water sample from the study area is a source of serious health concern.

Based on the findings of this study the following recommendations were made:

(i) Promotion of efficient water treatment/management techniques such as use of *Moringa Oleifera* seed as natural absorbent and antimicrobial agent of purification of ground water for drinking purpose.
(ii) Routine water quality assessment by water supply agencies, this will provide a baseline information on water quality which will aid sustainable water resource management at community level and will develop the capacity of local health agencies to map the incidences and occurrence of water borne diseases in the study area.
(iii) Creation of awareness and Integration of water quality assessment into the Primary Health Care (PHC) framework.

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