

Suitability Of Ground And Surface Water Resources For Different Uses In Boh Community Gombe State Northeastern Nigeria

¹S.K. Lovelyn, ^{2*}H. Hamidu, ¹E.Y. Mbiimbe, ³M.W. Sidi, and ⁴G.I. Farida,

¹Department of Geology, Gombe State University Gombe, Nigeria.

¹Department of Geology, Usmanu Danfodiyo University Sokoto, Nigeria.

³Department of Geology, University of Maiduguri, Maiduguri.

⁴Model Secondary School Usmanu Danfodiyo University Sokoto, Nigeria.

hassanhamidu@yahoo.com

Abstract: Twenty (20) water samples collected from dug wells boreholes and streams from Boh community of Shongom local government area of Gombe state in Nigeria were analysed for their hydrochemical parameters in February 2013, with an attempt to determine their suitability for different uses. The area is located within the Kaltungo inlier, underlain by the Precambrian basement and the sedimentary rocks of the Aptian-Albian Bima sandstone. The physical parameters of PH, temperature, Ec and TDS shows the water to be fresh water and within the WHO and NIS standard and utilizable for drinking and other domestic purposes. The chemical parameters analysed gives the following ranges for the anions Cl 10.98-173.62mg/l, F, 0.42-1.72 mg/l, NO₃, 18.62-219.27 mg/l, SO₄, 8.86-34.07 mg/l, CO₃, 0.00-5.20 mg/l and HCO₃, 157-427mg/l. The cations analysed gives ranges of values as Na⁺, 0.11-5.88 mg/l, K⁺, 2.16-9.60 mg/l, Ca²⁺, 33.6-72.02 mg/l, Mg²⁺, 31.16-68.77 mg/l, Fe³⁺, 0.022-2.98 mg/l. However, Pb and As concentrations are within the ranges of 0.00-0.001 mg/l and 0.00-0.005 respectively. All the above ranges of values are within the WHO (2011) and NIS (2007) set standards. Fecal coliform bacterial count ranges between 4-28cfu/100 ml with nine samples having concentration above the acceptable limit of 10cf/100ml making them not suitable for drinking. Seven samples have high NO₃ concentrations above the NIS standard of 50 mg/l indicating pollution from anthropogenic sources. The values of residual sodium carbonate (RSC), Sodium adsorption ratio (SAR) and Salinity reveals the water to be suitable for irrigation purposes. However the hardness values determined indicates the water to be hard and very hard which by classification is not suitable for industrial uses. Analysed samples revealed [CaMgHCO₃] as the only water type in the area with all the chemical parameters originating from the rocks in the area. [S.K. Lovely, H. Hamidu, E.Y. Mbiimbe, M.W. Sidi and G.I. Farida. **Suitability of Groundwater and Surface water resources for Different uses in Boh Community of Gombe state Northeastern Nigeria.** *Nat Sci* 2016;14(2):22-31]. ISSN 1545-0740 (print); ISSN 2375-7167 (online). <http://www.sciencepub.net/nature>. 4. doi:10.7537/marsnsj14021604.

Keywords: Hydrogeochemistry; Residual sodium carbonate (RSC); Sodium adsorption ratio (SAR); Groundwater; Basement Complex; Bima sandstone; Boh

1. Introduction

Once precipitation reaches the ground surface it reacts with soil, rock and organic debris, dissolving still more chemicals elements naturally, apart from pollution generated by human activities. Water quality thus must be considered in evaluating water supplies. All groundwater contain natural chemical constituents in solution, the type and quantity of constituents depend on the geochemical environment, movement and sources of the groundwater as well as the residence time of groundwater in the geological formation, Todd (1980). Typically concentrations of dissolved constituents in groundwater naturally exceed those in surface water. Besides solution of rock materials, other natural sources of salinity in groundwater include water of volcanic origins, evapotranspiration through native vegetation and airborne salts. Salinities tend to be higher in arid regions and where drainage is poor. Anthropogenic activities which indiscriminately add pollutants into the environment do contribute to the contamination of both groundwater and surface water consequently

altering their chemistry and degrading the quality. In the study area seasonal streams/river, hand-dug wells and boreholes are the main source of water supply. Similarly domestic, agricultural and industrial activities are carried out without due consideration of the chemistry of the water use.

Mboringong *et al* (2013) investigates the Arsenic concentration of the rock of northeast Kaltungo area, the discovered a high concentration range of 87.54-237.65 ppm compared with an average crustal abundance of 2ppm. They attributed this anomaly to high concentration in the initial magma and/or hydrothermal and weathering processes which has acted on the rock Abdulhakeem *et al* (2013) mapped the water quality index of Kaltungo using GIS and found two zones of water quality in the area; a poor and very poor zone, higher water quality index recorded were influenced by high values of nitrate, iron and coliforms. Lastly the degradation of water quality in the area was due to salinity, agricultural contamination, dissolution of bedrock material and bacteriological contamination.

Haruna *et al* (2014) studied the distribution of Fluoride in drinking waters from Kaltungo area, they recorded a concentration range of 0.55- 44 mg/l for fluoride in surface water, 0.1-3.95 mg/l for groundwater sources and a concentration range of 1.2-1.96 mg/l for plants samples, an average of 2.8 mg/l

for both surface and groundwater is high for the area. It is on this account that this research work is carried out so as to cover parts of NE and NW Kaltungo in shongom local government area in other to bridge the gap in the hydrogeochemistry study of the area.

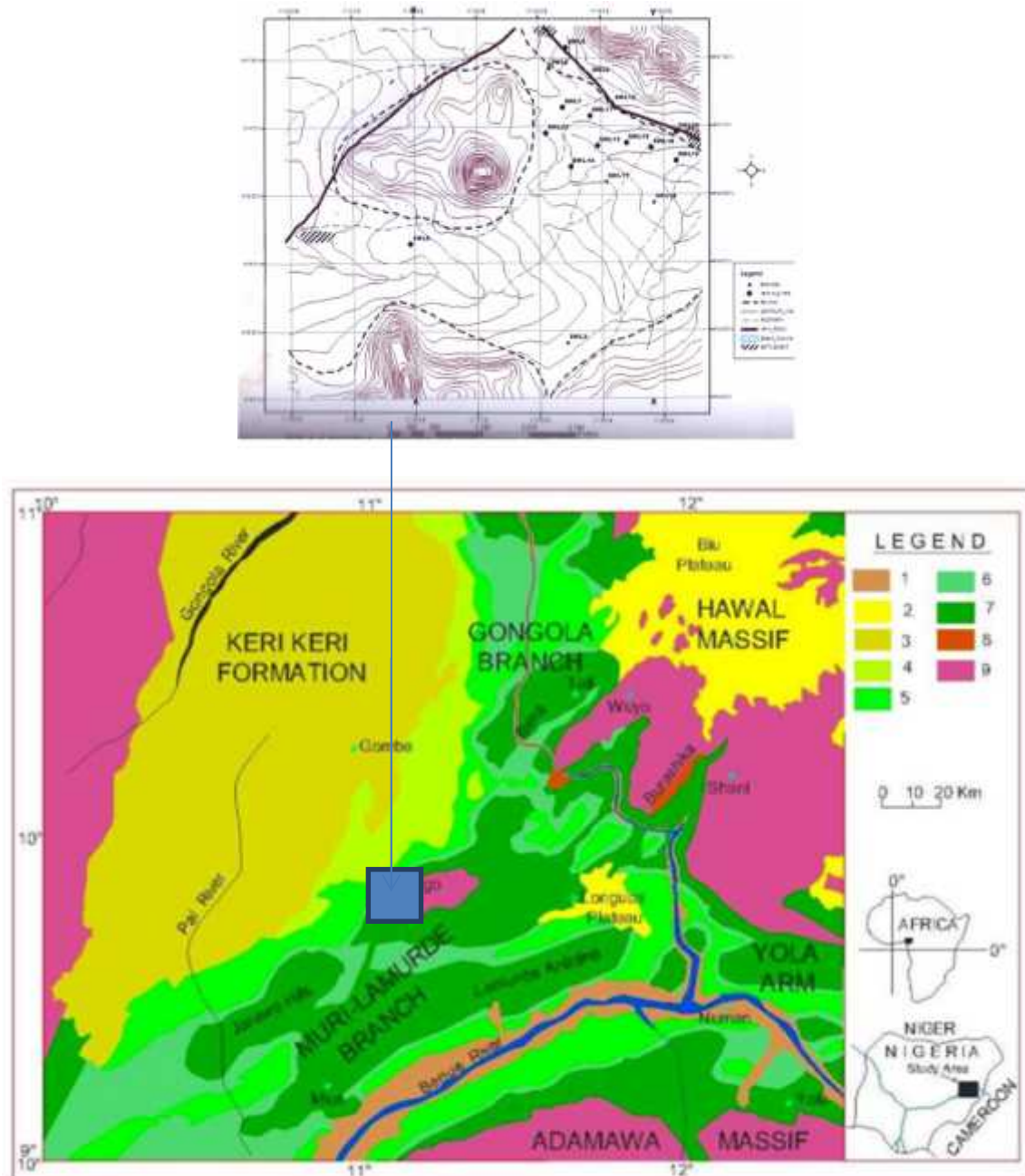


Figure 1: Geologic map of upper Benue trough showing the study area (modified after Haruna *et al* (2012) 1. Quaternary alluvium 2. Tertiary to recent volcanism 3. Kerri kerri formation 4. Gombe sandstone 5. Pendiga formation 6. Yolde formation 7. Bima sandstone 8. Burashika group (Mesozoic volcanism) 9. Granitoids pre-cambrian

2.0 Material and Method

2.1 Description of the Study Area

The study area is located in Shongom Local Government Area; and covers parts of sheet 173

Kaltungo NE and NW of the federal survey map of Nigeria on a scale of 1:50,000. It lies within Latitudes 9°45' N and 9°47'44"N and within longitudes 11° 13' 28" E and 11° 16' 48" E and covers an area extent of about 30km². The study area forms parts of the Yola arm of the Upper Benue Trough Northeastern Nigeria. The topography of the study area is characterized by hilly features with the area having an average height of 600m altitude above sea level. The drainage system in the area is the dendritic type. The vegetation cover consists of shrubs and short grasses and scattered trees described as a sub-Sahara savannah, Obaje (2000).

2.2 Geology of the study area

Gombe state is generally underlain by 6 different types of Formations, the approximate percentage of rocks in the State are; basement complex-2%, Bima Formation 31.1%, Yolde Formation 10.5%, Pindiga Formation 9.9%, Gombe Formation 10.3%, Kerri-Kerri Formation 34.2% and Alluvium 1.2%, Zaborski et al., (1997). The lithology of the area mapped comprises two major rock units and their approximate percentages are given below. The crystalline complex which is represented by older granite comprising of coarse porphyritic granites and biotite granites constitute 10% of the rock types in the area, the basaltic plugs outcrop in the south western, central and

south eastern parts of the study area occupying about 5% of the area. They occur within the sedimentary rocks that characterized the southern parts of the study area. Their contact with the Bima sandstone is well defined. The sedimentary rock identified in the area is Aptian-Albian Bima sandstone which occurs in the southern parts of the area, covering about 85% of the mapped area. It outcrops mostly in the southern parts as plains with some prominent hills. The sandstone is cream to Gray in color and varies from medium grained to very coarse-grained in texture. The Bima sandstone is characterized with Joints, Beddings and Faults, figure 1.

2.3 Hydrogeology

The aquifer in the area can be divided into confined and unconfined. From hydrogeological point of view, the stratigraphic sequence in Gombe State and environs from top to bottom is given in table 1. The hydrogeology of Gombe State can be discussed under two broad environments, the crystalline and sedimentary environment. Crystalline environment has 3 to 4 zones, decompose (mostly topsoil), weathered, fractured and fresh crystalline zones with water normally found within weathered and fractured zones Dike *et al.*, (1994).

Table 1: Lithology and storage of formations

S/No.	Formation	Lithology	Storage
1.	Kerri- Kerri	Mainly silt sandy clay and sandstone	Deep layer aquifer
2.	Gombe	Sandstone, siltstone, clay and ironstone	Aquifer-Aquicludes
3.	Pindiga	Shale with limestone	
4.	Yolde	Shelly clay, sandstone	Aquifer
5.	Bima	Feldsparthic sandstone, medium to coarse grained	Aquifer
6.	Basement	Granite, Gneiss	Weathered, fractured zone

The weathered zone has an unlimited water capacity, with thickness of about 10-40meters. While in fractures zone, the aquifer is very rich and its capacity depends on its thickness and lateral extend as well as the inter connectivity of the fractures (Dike et al. 1994). Crystalline rocks are found in Kaltungo and some part of Gombe inlier. The sedimentary environments contain different rock formations with different water content depending on soil type and source of recharge. Bima Sandstone is Feldsparthic sandstone, medium to coarse grained, therefore it can form good aquifer (Adegoke *et al.*, 1978).

2.3 Sampling analysis

A total of twenty water samples were collected in the field (three from streams sources, six from boreholes and eleven from dug wells) in the month of February 2013 and were sent to the laboratory for physical, chemical and bacteriological analysis. The physical parameters of temperature, P^H, total dissolved solids (TDS) and conductivity, turbidity and Odour

were determine insitu in the field using the HACH model conductivity metre while the PALIN Test PH metre was used to measure the PH. The turbidity and Odour were determined in the laboratory using HACH model spectrophotometer. The samples collected were found to be odourless and unobjectionable. The sampled water was analysed for coliform bacteria to deduce the health implications on humans and animals.

The Groundwater samples were also analyzed for major, minor and trace chemical elements which include: Na⁺, K⁺, Ca²⁺, Fe²⁺, Mg²⁺, NO₃⁻, F⁻, Cl⁻, HCO₃²⁻, CO₃²⁻, SO₄²⁻, Cd²⁺, As, Pb²⁺ and Fe³⁺. Other parameters analysed were alkalinity and total hardness. All these analyses were carried out in Adamawa State Water Board located in Yola, Adamawa State Nigeria. The method employed is the United State Environmental Protection Agency (USEPA) standards methods. A DR/200 Spectrometer (HACH model) was used to analyse the major

elements (cations) while titrimetric method was used for the analysis of the minor element (anions). Both the $MgCO_3$ and $CaCO_3$ made up the total hardness of water; this was also evaluated in the water samples taken. Sodium adsorption ratio and (SAR) and Residual sodium carbonate (RSC) were determined respectively using the following relations

The SAR of water samples can be calculated by using the equation below.

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

$$RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$$

All ionic Concentrations were expressed in milliequivalent/liters.

The result obtained from the water quality assessment was interpreted using the Rockworks computer software to plot both the Piper trilinear diagram for the classification of the water species and the Gibbs's diagrams for the identification of the possible sources of analyzed ions in the water from the study area.

3.0 Results Analysis and Discussions

The results for the physicochemical analysis is presented in table 2, 3, 4 and 5 below

3.1 Evaluation of water quality for domestic uses

The standards for drinking water are based on WHO main criteria (Davis and Dewiest, 1966). These are the presence of objectionable taste, Odour and colour and the presence of substances with adverse health effects. The dissolved geochemical constituents in drinking water are correlated with the World Health Organization (WHO), International Standards for drinking water (2011) and NIS (2007) to ascertain the suitability of the water for different purposes, table 5. Recorded physical parameter values in table 2 gives a PH. range of 5.6-6.0 which is slightly acidic. TDS measured from samples of water taken were between 97-424 mg/l, which according to Carroll (1962) is fresh. Fecal coliform bacterial count ranges between 4-28cfu/100ml with nine samples having concentrations above the value of 10cfu/100ml which is the acceptable limit set by authority. However apart from the exceeded coliform count in nine samples the remaining water samples are suitable and safe for drinking and other domestic uses.

3.2 Evaluation of water quality for irrigation Purpose

Table 2: Results of physical parameters measured in field

Sample NO.	Sample type	T ⁰ c	pH	Total Hardness (mg/l)	Electrical Conductivity μ S/cm	TDS Mg/l	Turbidity NUT	Cali form Count Cfu/100ml
WSL1	Stream	31 ⁰ c	5.6	222	440.3	299	27.10	23
WSL2	Stream	25 ⁰ c	5.6	271	409.5	269	9.78	17
WSL3	Borehole	30 ⁰ c	5.8	247	368	237	4.95	4
WSL4	Stream	33 ⁰ c	5.8	257	463	307	17.08	15
WSL5	Handdug well	29 ⁰ c	5.6	273	519	356	3.55	10
WSL6	Borehole	30 ⁰ c	5.9	307	301	198	3.12	6
WSL7	Handdug well	33 ⁰ c	5.8	392	362.1	247	36	28
WSL8	Handdug well	31 ⁰ c	5.7	411	233	141	2.15	6
WSL9	Borehole	30 ⁰ c	5.8	331	201	133	1.28	9
WSL10	Handdug well	29 ⁰ c	5.8	330	411	268	2.66	14
WSL11	Handdug well	30 ⁰ c	5.9	234	389.0	261	1.15	7
WSL12	Borehole	30 ⁰ c	6.0	355	449.7	319	6.42	13
WSL13	Handdug well	30 ⁰ c	5.8	290	271.3	178	4.55	16
WSL14	Handdug well	20 ⁰ c	5.9	213	449	301	1.57	5
WSL15	Handdug well	31 ⁰ c	5.9	270	139	97	1.46	11
WSL16	Handdug well	31 ⁰ c	5.9	217	189.6	131	5.02	6
WSL17	Borehole	28 ⁰ c	6.0	273	641	424	12.13	9
WSL18	Borehole	31 ⁰ c	6.0	266	330	221	1.95	17
WSL19	Handdug well	33 ⁰ c	5.9	256	249	162	3.2	9
WSL20	Handdug well	33 ⁰ c	6.0	462	147.9	101	9	5

The suitability of water for irrigational purpose is determined by the amount and Kinds of salts present. With poor water quality, various soil and cropping problems are bound to occur, unless appropriate soil or water amendments are applied. Water Quality problems with respect to irrigation, though often complex, can be classified into four categories Bernstein, *et al* (1974). These include, salinity, permeability, Toxicity and miscellaneous problems each of which may invariably affect the crop in combination or singly. The parameters of Salinity, Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) were used here to determine the suitability of the water from the area for agricultural uses.

Salt Content (mg/l)	Evaluation
<250	Excellent (water of best quality)
250 – 750	Good (water causing salinity and Alkalinity hazard)
750 – 2250	Permissible (water could be used for Irrigation only with leaching and proper drainage)
>2250	Unsuitable

The total dissolved solids (TDS) values of all the water samples analyzed in the study area range from 97-424mg/l. The values fall within two classes, the **Excellent** class, this includes water samples from

3.2.1 Salinity Problem

This is evaluated from the electrical conductivity of water, which is an adequate measure of salinity problem. If excess quantities of soluble salts are in the crop root zone, the crop has extra difficulty in extracting enough water from the salts solution. This reduces water intake by the plants, which can result in slow or reduced growth and symptoms similar to those that might result from drought Bernstein *et al*, (1974). Salinity hazard can also be determined based on total dissolved solids (TDS). The TDS is correlated with the criteria adopted in the (UNESCO/FAO, 1973) as given in table 6 below:

location 3, 6, 7, 8, 9, 13, 15, 16, 18, 19 and 20 making 55% while the **Good** class includes water sample location 1, 2, 4, 5, 10, 11, 12, 14 and 17 comprising 45% of the samples analyzed.

Table 3: Result of chemical Analysis in water expressed in (mg/l)

Sample NO.	HCO ₃ ²⁻	CO ₃ ²⁻	CL ⁻	F ⁻	Fe ²⁺	Pb ²⁺	Mg ²⁺	NO ₃ ⁻	K ⁺	Na ⁺	SO ₄ ²⁻	AS	Cd ²⁺	Fe ³⁺	Ca ²⁺
WSL1	298	2.50	90.11	0.54	1.33	0.00	31.63	73.17	3.98	0.17	21.11	0.00	0.00	2.88	37.01
WSL2	227	5.20	173.62	1.70	5.21	0.001	36.62	219.27	9.60	5.76	29.62	0.003	0.00	0.58	48.38
WSL3	316	1.80	21.80	1.46	0.86	0.00	34.68	51.62	2.80	0.48	20.16	0.00	0.00	0.24	41.76
WSL4	320	1.60	59.86	0.89	1.06	0.00	39.87	90.43	4.78	1.40	21.09	0.00	0.00	0.86	37.31
WSL5	335	3.10	39.80	1.21	0.93	0.00	43.27	47.83	4.10	2.33	22.05	0.00	0.00	0.17	38.11
WSL6	410	0.00	23.10	1.34	0.47	0.00	41.93	38.66	6.60	0.28	18.67	0.00	0.00	0.15	53.84
WSL7	209	4.80	113.81	1.63	2.11	0.00	57.88	109.67	8.77	4.83	34.07	0.001	0.00	2.98	70.11
WSL8	268	2.20	16.79	0.77	0.39	0.00	59.97	31.67	5.00	0.59	14.40	0.00	0.00	0.018	66.17
WSL9	266	0.00	20.01	1.13	0.29	0.00	49.08	18.62	3.84	0.09	8.86	0.00	0.00	0.022	52.07
WSL10	315	2.70	18.62	1.01	0.23	0.00	48.77	53.32	3.10	0.12	21.13	0.00	0.00	0.032	52.12
WSL11	157	1.80	29.67	0.51	0.41	0.00	37.01	41.01	4.00	0.11	24.00	0.00	0.00	0.03	33.06
WSL12	267	0.00	19.73	0.99	0.55	0.00	46.11	41.22	2.16	0.55	20.00	0.00	0.00	0.31	66.18
WSL13	260	1.10	38.83	1.07	0.33	0.00	46.17	29.82	5.20	0.41	10.13	0.00	0.00	0.16	40.11
WSL14	318	0.00	14.01	0.42	0.16	0.00	33.77	22.08	4.13	0.20	16.87	0.00	0.00	0.047	29.73
WSL15	309	1.40	20.43	0.92	0.22	0.00	39.09	31.07	4.56	0.16	15.93	0.00	0.00	0.047	44.00
WSL16	299	1.50	24.73	1.003	0.81	0.00	31.16	27.08	4.40	0.87	9.10	0.00	0.00	0.19	35.63
WSL17	248	0.00	10.98	0.93	0.11	0.00	39.89	19.72	4.70	0.23	20.93	0.00	0.00	0.58	43.88
WSL18	331	0.00	16.66	1.06	0.108	0.00	41.01	36.11	5.30	0.33	18.00	0.00	0.00	0.11	37.17
WSL19	300	1.20	14.40	0.68	0.21	0.00	37.33	28.83	4.26	0.22	16.83	0.00	0.00	0.07	41.03
WSL20	427	6.10	162.07	0.87	2.89	0.001	68.77	138.11	8.90	5.88	34.12	0.005	0.00	0.56	72.02

Table 4: Converted Values of the Chemical Analytical Results expressed in (meq/l)

Sample NO.	HCO ₃ ²⁻	CO ₃ ²⁻	CL ⁻	F ⁻	Fe ²⁺	Pb ²⁺	Mg ²⁺	NO ₃ ⁻	K ⁺	Na ⁺	SO ₄ ²⁻	AS	Cd ²⁺	Fe ³⁺	Ca ²⁺	SAR (meq/l)	RSC. meq/l)
WSL1	4.88	0.08	2.54	0.03	0.05	0.00	2.60	1.18	0.10	0.01	0.44	0.00	0.00	0.15	1.85	0.009	2.41
WSL2	3.72	0.17	4.90	0.09	0.19	0.00	3.01	3.54	0.25	0.25	0.62	0.00	0.00	0.03	2.41	0.216	8.46
WSL3	5.18	0.06	0.61	0.08	0.03	0.00	2.85	0.83	0.07	0.02	0.42	0.00	0.00	0.01	2.08	0.018	1.79
WSL4	5.24	0.05	1.69	0.05	0.04	0.00	3.28	1.46	0.12	0.06	0.44	0.00	0.00	0.05	1.86	0.053	3.38
WSL5	5.49	0.10	1.12	0.06	0.03	0.00	3.56	0.77	0.10	0.10	0.46	0.00	0.00	0.009	1.90	0.085	3.53
WSL6	6.72	0.00	0.65	0.07	0.02	0.00	3.45	0.62	0.17	0.01	0.39	0.00	0.00	0.008	2.69	0.008	2.85
WSL7	3.43	0.16	3.21	0.09	0.08	0.00	4.76	1.77	0.22	0.21	0.71	0.00	0.00	0.16	3.50	0.169	4.95
WSL8	4.39	0.07	0.47	0.04	0.01	0.00	4.93	0.51	0.13	0.03	0.30	0.00	0.00	0.0009	3.30	0.021	1.91
WSL9	4.36	0.00	0.56	0.06	0.01	0.00	4.04	0.30	0.10	0.003	0.18	0.00	0.00	0.001	2.60	0.002	1.53
WSL10	5.16	0.09	0.53	0.05	0.01	0.00	4.01	0.86	0.08	0.004	0.44	0.00	0.00	0.002	2.60	0.008	1.25
WSL11	2.57	0.06	0.84	0.03	0.01	0.00	3.04	0.66	0.10	0.02	0.50	0.00	0.00	0.002	1.65	0.004	2.49
WSL12	4.38	0.00	0.56	0.05	0.02	0.00	3.79	0.66	0.06	0.02	0.42	0.00	0.00	0.02	3.30	0.015	1.12
WSL13	4.26	0.04	1.10	0.06	0.01	0.00	3.80	0.48	0.13	0.02	0.21	0.00	0.00	0.009	2.00	0.017	2.52
WSL14	5.21	0.00	0.40	0.02	0.01	0.00	2.78	0.36	0.11	0.01	0.35	0.00	0.00	0.003	1.48	0.010	2.74
WSL15	5.06	0.05	0.58	0.05	0.01	0.00	3.22	0.50	0.12	0.01	0.33	0.00	0.00	0.003	2.20	0.009	2.34
WSL16	4.90	0.05	0.70	0.05	0.03	0.00	2.56	0.44	0.11	0.04	0.19	0.00	0.00	0.01	1.78	0.038	3.34
WSL17	4.06	0.00	0.31	0.05	0.00	0.00	3.28	0.32	0.12	0.01	0.44	0.00	0.00	0.03	2.19	0.009	2.32
WSL18	5.43	0.00	0.47	0.06	0.00	0.00	3.37	0.58	0.14	0.01	0.37	0.00	0.00	0.001	1.95	0.009	2.74
WSL19	4.92	0.04	0.41	0.04	0.01	0.00	3.07	0.47	0.11	0.01	0.35	0.00	0.00	0.003	2.05	0.009	2.29
WSL20	6.99	0.20	4.57	0.05	0.10	0.00	5.66	2.23	0.23	0.26	0.71	0.00	0.00	0.03	3.59	0.171	5.03

Table 5: WHO (2011) and NIS (2007) International and National Standards for Drinking and Domestic uses for water

S/No	Parameters	UNITS	WHO's 2011 Standard	NIS 2007 Standard	AUTHOR'S Result 2014	Average
1	Appearance		Clear			
2	Temperature	°C	30 – 32		20-33	29.9
3	p ^H	-	6.5 – 8.5	6.5-8.5	5.6-6.0	5.55
4	Conductivity	µS/cm	1000	1000	139-641	341
5	Colour	TCU	15pcu	15		
6	Turbidity	NUT	<5	5	1.15-27.10	7.22
7	TDS	mg/l	600- 1000	500	101-424	232
8	Total hardness	mg/l	≤ 500	150	213-482	283
9	Calcium, Ca	mg/l	100		29.73-72.02	53.3
10	Magnesium, Mg	mg/l	50	0.2	31.16-68.77	43.2
11	Potassium, K	mg/l	150 – 120mg/l		2.16-9.60	5.01
12	Sulphate, SO ₄	mg/l	250	100	8.86-34.12	20.0
13	Chloride, Cl	mg/l	250	250	10.98-173.62	46.45
14	Iron, Fe, Total	mg/l	0.3	0.3	0.16-5.21	0.52
15	Bicarbonate, HCO ₃	mg/l	1000mg/l		157-427	294
16	Carbonate, CO ₃	mg/l	120mg/l		0.00-5.20	1.85
17	Copper, Cu	mg/l	2	1		
18	Nitrite NO ₂	mg/l	3	0.2		
19	Nitrate NO ₃	mg/l	50-100	50	18.62-219.27	57.05
20	Phosphate, P	mg/l	10			
21	Manganese, Mn	mg/l	0.1	0.2		
22	Cadmium, Cd	Mg/l	0.003	0.003	0.00-0.00	
23	Lead, Pb	Mg/l	0.01	0.01	0.00-0.001	0.0001
24	Arsenic, As	Mg/l	0.01	0.01	0.00-0.005	0.00045
25	Fluoride, F	mg/l	1.5	1.5	0.42-1.63	1.01
26	Sodium, Na	mg/l	200	200	0.11-5.88	1.30
27	Zinc, Zn	mg/l	0.1	3		
28	Salinity	mg/l	2000mg/l			
29	Coliform bacteria	Cfu/100ml	0	10	4.0-28	11.5

They two classes' suite the quality for irrigational purposes. The electrical conductivity (EC), have values ranging from 139-641µs/cm. The criteria for evaluating salinity hazards as given by the California fertilizer committee (1975) base on EC table 7:

Electrical Conductivity (µs/cm) Evaluation

Less than 0.75 irrigation water has no salinity problem 0.75 – 3.0 increasing problems expected.

Greater than 3.0 will cause severe problems accepts for areas restricted to only few tolerant crops.

The above classification shows that the water within the study area falls under the third class >3.0 which will cause severe problems except for areas restricted to only few tolerant crops.

3.2.2 Sodium adsorption ratio (SAR)

This measures the extent of replacement of calcium and magnesium by sodium ions, which are the amount of sodium adsorbed by the soil, resulting in the deflocculating of the soil. Results of analysis from the above table are correlated with the standard SAR

values based on USSL classification (2010) and by Mandel and Shiftan (1981) which is given in the table 8

below.

Class	SAR	Quality	Uses
I	<10	Low SAR	Use for all soils
II	10-18	Medium SAR	Preferably used on Coarse texture soil, with low porosity.
III	18-26	High SAR	May produce harmful effect, Good soil management is essential.
IV	26-100	Very high SAR	Unsatisfactory for irrigation Purpose.

The SAR values for all the water samples from the study area ranges from 0.002 to 0.216meq/l. Hence the entire water sample from the study area fall under the first class which ranges from 0-10, and can be utilized for irrigational purposes on all soils under the agricultural purposes.

3.2.3 Residual Sodium Calcium Carbonate (RSC C)

Carbonate is a quick test to determine if irrigation water can reduce free in the free Calcium and Carbonate content. Water containing a Carbonate plus Bicarbonate Concentration greater than the Calcium plus Magnesium Concentration have what is termed "Residual Sodium Carbonate." RSC C predicts the

accumulation of Sodium in the soil based on the potential precipitation of Calcium/Magnesium Carbonate. The Principal Cations are: Calcium, Magnesium, Sodium and Potassium and Principals Anions are: Carbonate, Bicarbonate, Sulfate, and Chloride respectively in the determination of RSC C. Their parameter qualifies the ratio of Sodium to Calcium and Magnesium in terms of the ability of the Sodium to dominate, table 3. According to the USSL Classification of groundwater for irrigation (2010) given below table 9, the above table 8 will be compared and conclusion made.

RSC (meq/liter)	Water Class
<1.25	Safe (Low, with some removal of Calcium and magnesium from irrigation water).
1.25 – 2.50	Moderate (Medium, with appreciate removal of calcium and magnesium from irrigation water).
>2.50	Unsuitable (High, with most calcium and magnesium removed Leaving sodium to accumulate).

In the study area Residual Sodium Calcium Carbonate (RSC C) values range from 1.12-8.46meq/l. Water Sample Location 10 and 12 falls within the class of Safe water for irrigation make up only 10%. Water Sample Location 1, 3, 8, 9, 11, 15, 17 and 19 falls within the class of Moderate water for irrigation constituting 40%. Water Samples Location 2, 4, 5, 6, 7, 13, 14, 16, 18 and 20 falls within the class of Unsuitable water for irrigation taking 50% of the analyzed samples. Base on table only 50% of the water samples are safe to be use for irrigation purpose.

3.3 Evaluation of water quality for Industrial uses

According to Okafor (1991) water for industrial use should be odourless, colourless, and free from suspended matter and micro-organisms and should be of low iron and manganese contents. Water used in boiler should be soft and non-corrosive while laundry water should be soft and colourless. Iron and manganese concentrations above 0.2mg/l precipitates upon oxidation and causes stains on plumbing fixtures and foster growths in reservoir filters and distribution

systems Todd, (1980). Most industrial users object to water containing more than 0.2mg/l.

3.3.1 Hardness

This is the sum of calcium and magnesium concentration, expressed as gypsum equivalents. The hardness, classification of water after Twort et al (1994) is shown in table 10 below:

From the study area the value of hardness ranges from 213-462mg/l, which from the above description, all the water samples in the study area are classified as **Hard** and **Very Hard** water. **Hard** water from the area constitutes 65% and includes: samples 1, 2, 3, 4, 5, 11, 13, 14, 15, 16, 17, 18 and 19. **Very Hard** water from the area include: samples 6, 7, 8, 9, 10, 12 and 20 which constitute 35% of the samples. The above results of hardness indicates that the water of the study area is a hard water and therefore not suitable for industrial uses. Todd (1980) indicates salinity, hardness and silica composition of groundwater to be the determinants for the use of water for industrial purpose.

Table 10: The Hydrogeochemical Facies of Different Water Sources in the Study area.

Sample Location	Sample Type	Dominants Cations	Dominants Anion	Hydrogeochemical Facies
WSL3	Borehole	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL6	Borehole	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL9	Borehole	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL12	Borehole	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL17	Borehole	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL18	Borehole	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL5	Handdugwell	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL7	Handdugwell	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL8	Handdugwell	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL10	Handdugwell	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL11	Handdugwell	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL13	Handdugwell	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL14	Handdugwell	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL15	Handdugwell	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL16	Handdugwell	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL19	Handdugwell	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL20	Handdugwell	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL1	Stream	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL2	Stream	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type
WSL4	Stream	Calcium/Magnesium	Bicarbonate	Ca ²⁺ -Mg ²⁺ - HCO ₃ ²⁻ type

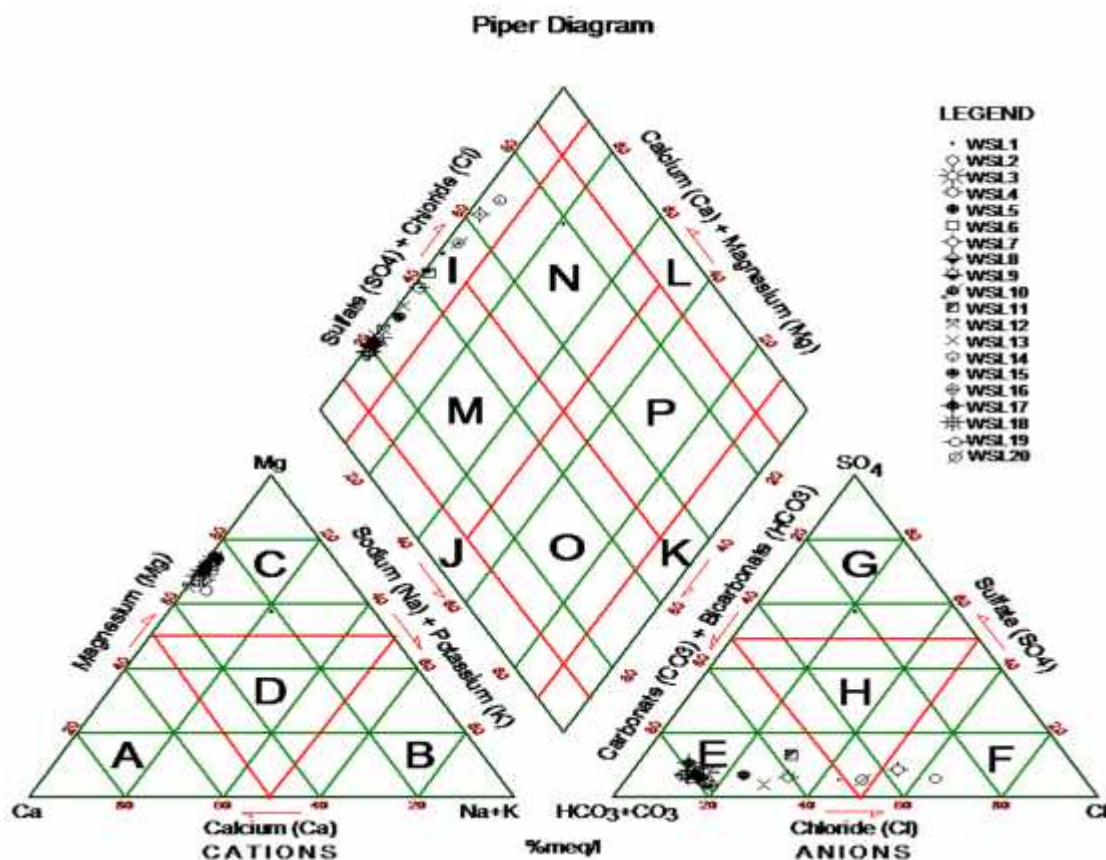
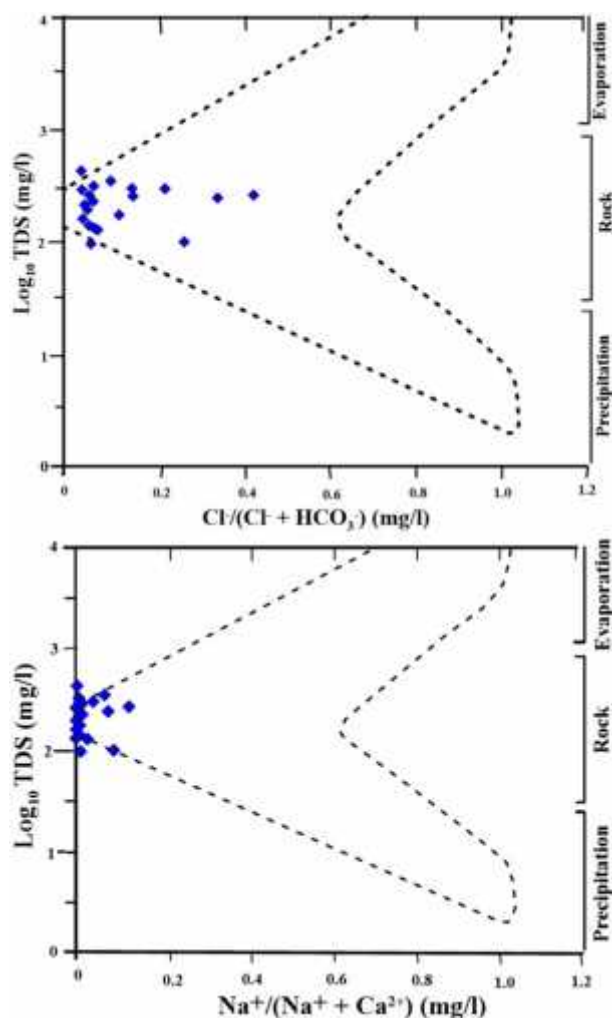


Figure 3: Piper Trilinear diagram for water types in the area.



Figures 4 & 5: Gibbs's diagram for the source of chemical enrichment in the waters of the study area.

Hardness Description (mg/l)	Water Class
0 – 50	Soft
50 – 100	Moderately Soft
100 – 150	Slightly Hard
> 200	Hard
> 300	Very Hard

3.4 Hydrogeochemical facies

Distinct zone of water that contains both cation and anion concentrations is referred to as hydrogeochemical facie (Back, 1961). Results of chemical analysis are presented graphically for easier understanding using piper's trilinear diagram to characterize the water in the area. The piper diagram and the result of the Hydrogeochemical facies in the area are given in figure 3 and table 11 respectively. The dominant and only facie analysed from the samples is magnesium bicarbonate water type (Ca^{2+} - Mg^{2+} - HCO_3^{2-}). The interpretation of the piper plot

shows the water from the area to be water of primary hardness which is water found in unconsolidated aquifers with abundant carbonate minerals. This is in agreement with the values of hardness calculated for the area and the ranges given in table 10.

3.5 Chemical parameters sources

The Gibbs's (1970) plot was used to show the sources of the dissolved chemical elements, as to whether they originated from precipitation, Rock or Evaporation. The TDS is plotted against the ratio of the cations and anions which are represented by $[\text{Na}^+; (\text{Na}^+ + \text{Ca}^{2+})]$ and $[\text{Cl}^-; (\text{Cl}^- + \text{HCO}_3^-)]$ respectively. The result obtained from this plot indicates a rock source origin for the dissolved chemical elements (figure 4 and 5) which probably resulted from chemical weathering process of the rocks.

3.6 Groundwater Pollution

Nitrate (NO_3) which when present in water indicates pollution, this was measured in the water samples collected with seven samples have abnormal high concentrations above the (NIS 2007) set standard of 50 mg/l. These high values were obtained from all the three water sources analysed with the highest values recorded from the streams. Three out of dug well samples have values above the limit while only one sample from boreholes has value above the set limit. The NO_3 detected were added to the water as a result of human activities and land use practices capable of polluting both surface and groundwater bodies which includes, improper waste disposals, application of fertilizers, manure and pesticides on farmlands, these can find their way into the water sources which are not covered or protected notably the open dug wells and streams sources or through gradual percolation process into the groundwater body. The average NO_3 value of 50.05 mg/l computed for the area is an indication of pollution in the area.

4. Conclusion

The physicochemical study of both surface and groundwater of Boh town and its surroundings shows that they are within the WHO (2011) and NIS (2007) standards except for calculated hardness of the water samples and coliform bacteria count in some of the samples, exceeded the permissible limit set. However water from eleven samples analysed in this area can be used for both drinking and domestic purposes because of the low coliform count values recorded in them and also suitable for irrigation, based on the concentrations of both physical and chemical elements detected and certain indices that were determined. For industrial uses the water quality is questionable due to its hardness. Water type analysis shows the water to be predominantly Calcium magnesium bicarbonate water

facie type, signifying water of primary hardness associated with carbonates rock or unconsolidated sedimentary rocks with abundant carbonate minerals. Analysis has also shown that the chemical parameters in the water samples are product of chemical weathering of the rock type in the area of study.

References

1. Abdulkareem, A, Ishaku J. M, Ahmad A.S (2011). Mapping of water quality index using GIS in Kaltungo, Northeastern Nigeria. *Journal of environmental science and resources management*. Vol.3 pp 94 – 106.
2. Adegoke, O.S, Jan du chene R.E, Aquamanu A.E, and Ajaji P.O. 1978.
3. Back W. (1961): techniques for mapping of Hydrochemical Facies U.S Geological survey Prof. Paper. 424pp 380 – 382.
4. Benstein *et al*; (1964); Interaction effect of saline water and fertility in yield of grains and vegetables. *Agro Journal* pp 9931- 943.
5. Davis S. N and De Weist R. J. M. (1966); *Hydrogeology*. John Wiley and sons New York p. 463.
6. Caroll. D. (1962) Rainwater as a chemical agent of geological processes. A review U.S Geological survey water supply paper 1535-G 18pp.
7. Dike E.F.C, Shemang E.M and Dan-Hassan M.A. (1994). Water Exploration in A.T.B.U. Main Campus at Gubi using Electromagnetic and Resistivity Techniques. An unpublished report, pp 1-10.
8. Gibbs. R.J (1970) Mechanism controlling world water chemistry, science. 1088-1090.
9. Haruna, A.I, Usman, A. M, and Abdullahi, A.M (2014). Environmental distribution of fluoride in drinking water waters of Kaltungo area, North-Eastern Nigeria. *American journal of Environmental protection a science publishing group publication* 3(6-2):19-24.
10. Haruna, I. V., Ahmed, H.A. and Ahmed, A.S. (2012) Geology and tectono- Sedimentary disposition of the Bima sandstone of the Upper Benue trough Nigeria: implication for sandstone-hosted uranium deposits. *Journal of geology and mining research*. vol 4(7) pp.168-173.
11. Mboringong M. N, Olasehinde A, Tabale R.P, Yusuf. A and Ashano. E.C (2013) Evaluation of Arsenic Concentration in Rocks of Kaltungo Area, Upper Benue Trough, Nigeria. *Journal of natural sciences research* vol.3 No4: 25-30 pp.
12. Nigerian Industrial Standard 554 (2007) Nigerian Standard for drinking water quality.
13. Obaje N.G, Olu, O.K, Maigarix A.S. and Abubakar M.B. (2000): Sequence stratigraphic and paleoenvironment interpretations of heteroliteids from the Pindiga Formation, Upper Benue Trough, North Eastern Nig. *J. Min. Geol.* V. 36, pp191-198.
14. Okafor D. U. and Adamu, E. A (1991); Aspect of the Geology and Hydrogeology of the River Bakoji catchments area of Niger state, Nigeria *Journal of Mining and geology*. Vol 2 pp 9.
15. Shiftan. Z.I and Mandel.S (1981) *Groundwater Resources Investigation and development*, Accademic press, Inc.
16. Todd D.K. (1980); *Groundwater hydrology* (2nd ed); J Wiley and Sons New York pp 535.
17. Twort *et al* (1994); *Water supply* Edward Arnold Publishers Ltd London; 511p.
18. UNESCO/FAO, (1973); *Irrigation drainage and Salinity*. An International Source book Paris/UNESCO Hutchinson and Co. Ltd.
19. WHO (2011) *Guideline for drinking water quality* fourth edition. A publication of the World Health Organisation Gutenberg pp 468-475.
20. Zarboski, P.M.P., Ugodulunwa F., Idorningie A., Nnabo P., Ibe, K. (1997). Stratigraphy and structure of the cretaceous Gongola Basin, Northeastern Nigeria. *Bulletin in centres research exploration- production Elf- Aquitaine* Vol.21: 153-185.

1/27/2016