International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2019): 7.583

Assessment of Groundwater Quality for Domestic and Irrigation Purposes in an Arid Zone of North Eastern Nigeria

Galadima, A, L[1], Nguru, A, I[2], Garba, M, L[3]

[1]Federal Ministry of Water Resources, Abuja, Nigeria

[2]Department of Geography, Yobe State University, Damaturu, Nigeria

[3]Professor, Department of Geology, Ahmadu Bello University, Zaria, Nigeria

Abstract: ***Assessment of groundwater quality and its suitability for domestic and irrigation purposes was carried out in Karasuwa in the Chad Basin formation of North Eastern Nigeria. Ground water is the major source of water for domestic and irrigation activities in the study area. The ground water sample was sampled f m 17 boreholes, 2 hand dug well and a stream during rainy season and dry season of 2016 and 2017 respectively, the water sample were analysed using the atomic absorption, flame emission, colorimetric and titrimetric methods for its physical and chemical characteristics and also its suitability for domestic and irrigation activities base on salinity hazard, sodium percentage, sodium adsorption ratio residual Sodium Carbonate US salinity diagram, Wilcox diagram kenys ratio and ermeability index Ca-HCO3 Ca-Mg-Cl and Na-Cl were the dominant groundwater types and electrical conductivity in the area with no hardness make the groundwater suitable for drinking and agricultural uses. Concentration of Major cation (Na+ K+ and Mg2++) Major anions(NO3,Po4) and heavy Matel (Cd and Ni) did not exceed the permissible limit for drinking and irrigation uses except Pb which is above WHO 1996 standard of 0.002mg/l in almost all sample collected from both stream and groundwater samples but almost all physio chemical parameters were within permissible limit and are therefore suitable for domestic and agricultural purposes.***

Keywords: Borehole, Chad Basin, Domestic, Dugwells, Groundwater, Irrigation, Karaswa, Stream, WHO

1. Introduction

1.1 Background to Study

Groundwater is one of the most important resources for human life. Its importance depends partly on its quality for the intended use; water quality depends upon the geological environment, it natural movement, recovery and utilization. The availability and access to fresh ground water is an important issue all over the world, since it constitutes the only reliable water supply for drinking and irrigation purposes. Hence understanding the groundwater quality changes, solute transport mechanism and identifying recharge areas in the groundwater zone has become important in protecting human health. This is because groundwater contains a wide variety of dissolved inorganic species in various concentrations as a result of the biochemical interactions between the water and geological materials through which it flows and to a lesser extent because of contributions from the atmosphere, surface water bodies and anthropogenic activities. Extensive work has been carried out on Chad Basin which includes the works of Barber and Jones (1960) (1965) on pressured water in Chad Formation, Camalt and Tibbits in (1963) on water level and artesian pressure of some boreholes in chad basin, followed by the work of Miller *et al*. (1968) on the characteristics of upper and middle zone aquifers, and that of Ndubussi (1990) and Adamu (2016) to determine the rate of decline of groundwater in upper, middle and lower aquifers as a result of heavy abstraction.Most part of the Northern Nigeria, the dominant source of drinking water for domestic uses is from boreholes, hand dug wells, river, streams and ponds. Where boreholes are properly sited, the water is less susceptible to human pathogens like cholera, typhoid, dysentery guinea worm and many others. The major problem of groundwater is its chemical content which must be analysed to ascertain if the dissolve ions in the water fall within the permissible limit for consumption as proposed by the World Health Organisation (WHO) and Nigerian Industrial Standard of Drinking Water Quality (NISDWQ) 2007.

The rapid increase of population growth has raised the demand for potable water for rural people in some areas especially during dry season, a period where the demand for water is high because of domestic and irrigation activities. In some rural areas, (the study area inclusive) women travel for some kilometres to search for and fetch water from the streams, ponds, rivers and open well, that might be contaminated with pathogens which may cause deadly disease to the rural population.This and many others did not give a clear insight on the quality of the groundwater.

This research is therefore, aim to assess groundwater quality of the study area and determine its suitability for domestic and irrigation uses with the objectives to predict the Hydro chemical analysis of groundwater which will entail the analysis of water to determine its suitability for both domestic and Irrigation purposes

1.2 Location of Study Area

The proposed area of study is located between latitude 12°45'N to 13°00'N, and longitude 10°30'E to 10°45'E on Gogaram sheet 40 Northwest. The area is accessible by various major/minor roads and footpaths network linking the villages around the area.

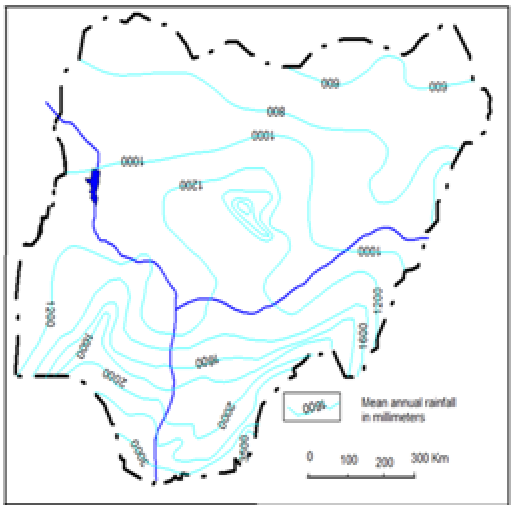

Figure 2: Rainfall map of Nigeria (After Schoeneich, 1998)

Hydrogeology of Chad Basin

The hydro stratigraphy and hydro dynamics of the area play a vital role in the recharge of the lake. Omali (2011) pointed out that the upper aquifer of the south west portion of the basin consists of a quaternary phreatic aquifer which is made up of fine-grained (Servant and Servant, 1983). Dune remnants are still present causing an irregular relief in the Lake Chad basin, especially along the eastern shore. Maduabuchi *et al*. (2006), undertook some groundwater investigations in the Nigerian sector of the Chad Basin and presented a brief description of the geologic and hydro geologic settings of the Chad Basin. John (1960), Baber *et al.* (1965), Miller 1968, Adamu*et.al*. (2007), Global Water Partisanship (2013). The basin contains three major permeable aquifer units separated by confining clay beds, which represent lake bed deposition from times during which the lake was much larger. The Lower Zone confined aquifer is comprised of sand and clayey sand. The upper aquifer at 30 to 100 m depth has yield of 2.5 to 30 l/s. The Middle Zone confined aquifer of the Chad Formation is comprised of fine to very coarse, uncemented sand. The middle aquifer is about 40 to 100 m thick having a yield of 24 to 32 l/s and a lower aquifer consisting of sands and clays at a depth of 425 to 530 m with yield of 10 to 35 l/s Akujieze*et al*. (2003), British Geological Survey, (2003).

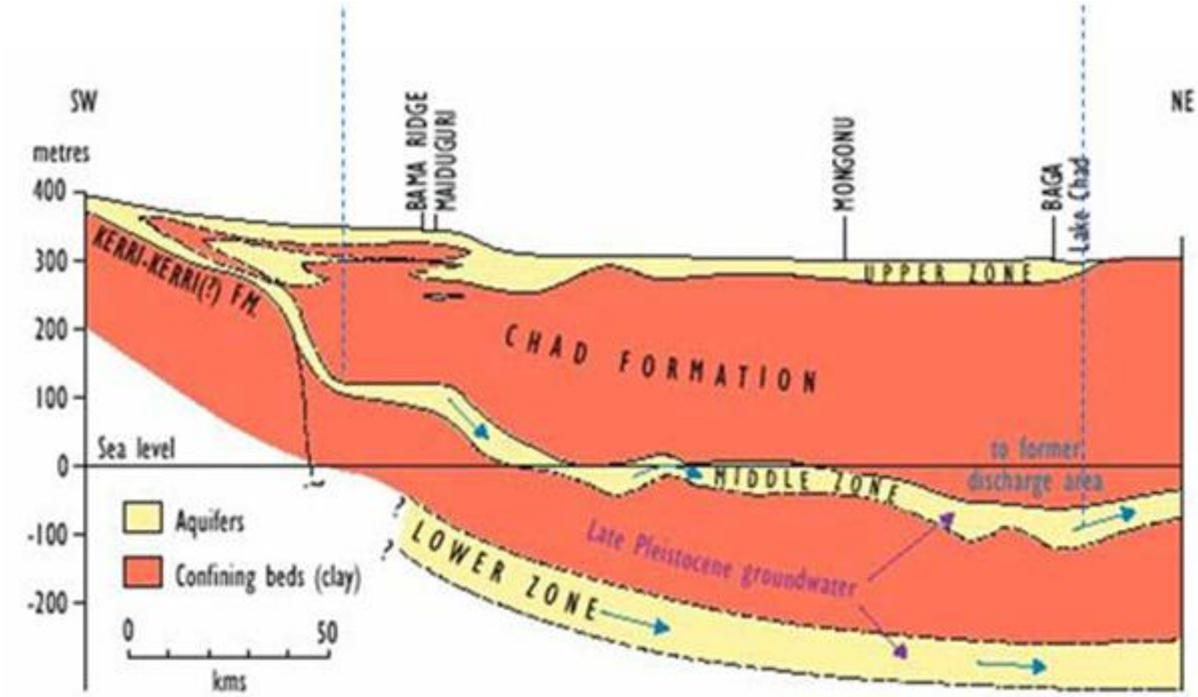

Figure 3: Geologic cross-section of the Lake Chad basin, showing the upper and middle aquifer zones within the Chad formation, separated by confining units (After Kolawale, *et al.*, (2012)

The Upper Zone consists of interbeded sands and clays that underlie most of the Lake Chad Basin region. This upper aquifer is considered to be unconfined. In the past twenty years, there has been a continuous lowering of the water table, as well as a reduction in the size or piezometric head of the confined aquifers, Adamu (2016).

2. Materials and Methods

The field work covered a period of seven months (October 2016- April 2017). This period included both the end of rainy season (October) and end of dry season (April) and it was carried out in three stages; desk studies, field work and laboratory analysis.

Data from various agencies like the Lake Chad Research Institute, Borno State Agricultural Development Authority, Yobe State Ministry of Water Resources, Yobe state Agricultural development authority, Federal Ministry of Water Resources and the Nigerian Hydrogeological Agency were consulted. Other relevant information where obtained from existing literatures such as text books, journals, and lecture notes.

2.1 Water Sample Collection

A total of twenty (20) water samples were taken from seventeen (17) boreholes, two (2) hand dug wells and one (1) river for hydrochemical analysis (Figure 12) in order to have a wide coverage. The sample bottles were thoroughly washed and rinsed three to four times with the water been sampled before filling the bottles. Two separate samples were collected from each water point one for anions determination while the other for cation determination. The samples collected for cation determination were acidified with concentrated nitric acid (HNO_3) to a pH of approximately 2. This is done in order to reduce the adsorption of ions to the wall of the container from solution. Samples were then preserved in fridge before being taken to laboratory for analysis.

At each sampling point, certain physical parameters such as temperature, electrical conductivity and pH were measured in-situ using thermometer, portable electrical conductivity cell and a pH meter. This was done because their value might change significantly soon after collection. Data for the parameters measured, time of measurement, location name and numbers were all recorded.

2.2 Laboratory Work

2.2.1 Physiochemical analysis (water samples analysis)

Analysis of the collected water sample, for their major cation, and anion, component, was carried out at Regional laboratory, Gombe, Federal Ministry of Water Resources laboratory and the Multiuser laboratory A.B.U Zaria. Where some cations, anions and heavy metals were analysed.

3. Results and Data Interpretation

Data obtained from the field which include measured Physical and chemical parameters, and water level measurement were evaluated. The data obtained were used to plot geological map, drainage and sampling point map and hydrogeological maps. Also Schoeller, Wilcox and Gibbs diagrams were produce for both wet and dry seasons respectively.

Hydrochemistry

The results obtained for physical and chemical parameters of water samples from the study area are presented in comparison to the World Health Organization (WHO, 2011) and Nigeria Industrial drinking water Quality Standard (NSDWQ 2007) guidelines respectively.

Physical parameters

From the results obtained the pH of groundwater samples in the study area are slightly acidic to slightly basic and ranges from 6.5 to 8.7 with average mean of 7.6. The water samples have a pH within the guideline range of 6.5 to 8.7. Groundwater temperature varies between 27 ^{0}C to 34.4 ^{0}C with a mean of 30.7 ^{0}C. Specific electric conductivity values of 126µs/cm to as high as 1150µs/cm were recorded with an average is 1000µs/cm. The corresponding values of total dissolved solids (TDS) measured in-situ range from 63mg/l to 525mg/l with a mean of 500mg/l. The static water level (SWL) ranges from 10.5 m to 15.7m with average of about 13.1 m in dry season (Table 4) and ranges from 11 m to 26 m with average of about 18.5 m in wet season (Table 5).

Chemical parameters

Cations

Sodium (Na+) occurs in concentration that ranges from 2.2 mg/l to 20 mg/l with a mean of 11.1 mg/l this fall within the permissible limit (<50 mg/l) NSDWQ (2007). Potassium (K^+) has concentrations varying from 6.7 mg/l to 12 mg/l with a mean of 9.35 mg/l. Calcium (Ca^{2+}) concentration ranges from 0.238 mg/l to 11.408 mg/l with mean value of 5.82 mg/l which is within the permissible limit. Magnesium (Mg^{2+}) concentration ranges from 3.05 mg/l to 13.96 mg/l with a mean of 8.5 mg/l. Copper (Cu) has concentration ranges from 0.008-0.01mg/l with an average of 0.009mg/l which is within the permissible limit. Zinc (Zn) occurs in a concentration ranges from 0.1-8.65mg/l with an average of 4.4mg/l which is above permissible limit. Iron (Fe^{2+}.) occurs in concentration ranges from 0.21 to 7 with an average of 3.61mg/l which are above permissible limit which makes the water not suitable for drinking and for making laundry. For the major anions, Nitrate (NO_3) concentration ranges from 0.20 mg/l to 84.6 mg/l with mean of 44.4 mg/l with location like Malari, Zolo, and Atta which are above permissible limit of 50mg/l of (NO_3) respectively Phosphate (PO_4) concentration ranges from 0.94mg/l to 4.7mg/l with an average of 3.29mg/l this fall within the permissible limit and therefore is suitable for drinking. Sulphate occurs with concentration ranges from 2.0-20 mg/l with an average 11.0 mg/l which is within the permissible limits.

Sodium adsorption Ratio (SAR) and the Suitability of the Water for irrigation

SAR is calculated using the formula, SAR =

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

However using the above formular the SAR of three (3) selected samples Na, Ca, and Mg (Table 7) was calculated with the values of 1.273, 1.407, and 1.882 respectively when compared with the standard value of 4.6 it showed that the water is very good for both irrigation and domestic use.

Figures 10 and 11 showsWilcox plots after Wilcox, (1962) which is a plot of Sodium Hazard (SAR) on the Y-axis vs. Salinity Hazard (conductivity) on the X-axis This figure shows that nineteen (19) of the samples are excellent for irrigation with conductivity of (< 250 µs/cm); one (1) of the sample is moderately good for irrigation with conductivity range (750-2250 µs/cm) during wet season figure 10.

While during dry season eighteen (18) samples are excellent for irrigation with conductivity ranges of (< 250 µs/cm) and two (2) samples are moderate for irrigation with conductivity ranges of (750-2250 µs/cm) figure 19.

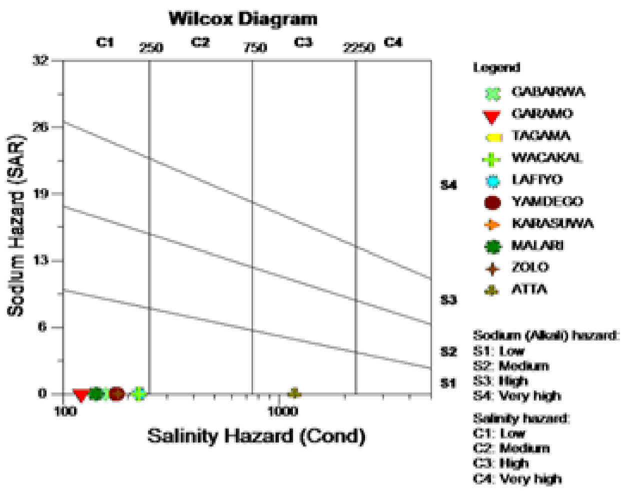

Figure 10: Wilcox plot for water samples from the Study area during wet season

Conductivity (us/cm) C1: Low (0-249), C2: Medium (250-749), C3: High (750-2249), C4: Very High (2250-5000). The values are divided into the following categories; S1: Low, S2: Medium, S3: High, S4 Very High. The locations of the SAR lines are determined by the following equations; S1: line equation: y= -1.5816e-3x+10.15816, S2: line equation: y= -2.2959e-3x + 18.229, and S3: line equation: y= -3.0102e-3x + 26.30102.

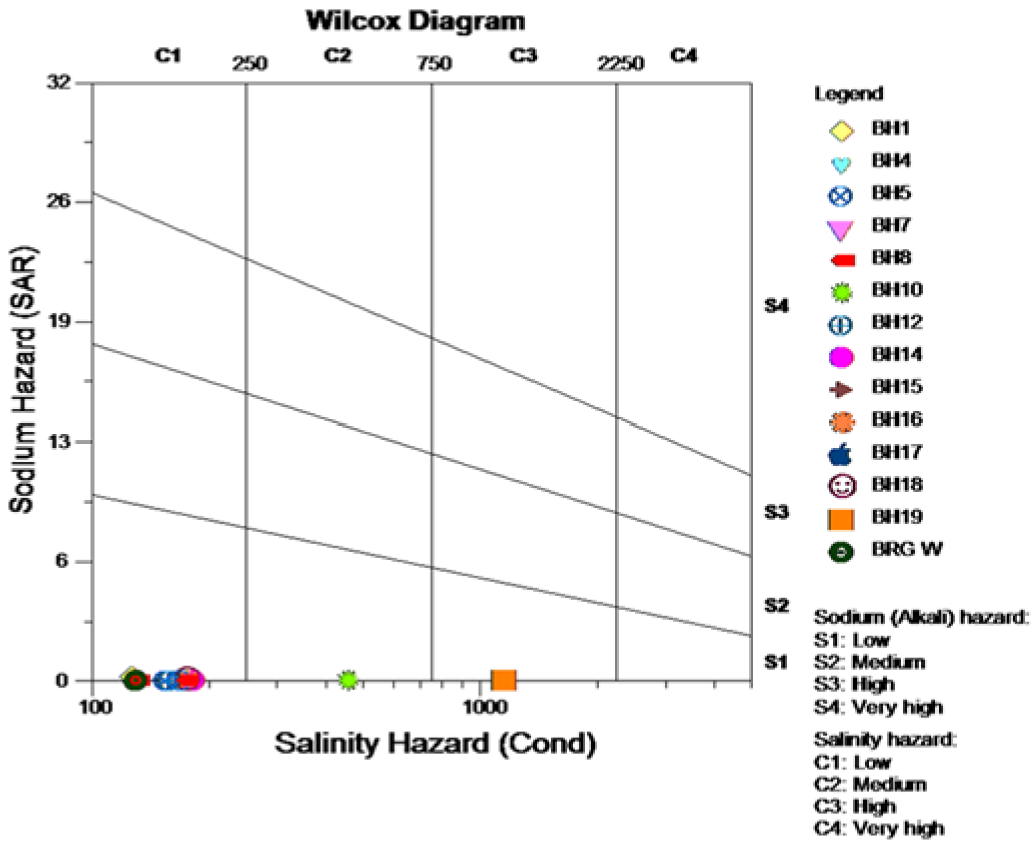

Figure 11: Wilcox plot for water samples from the study area during dry season.

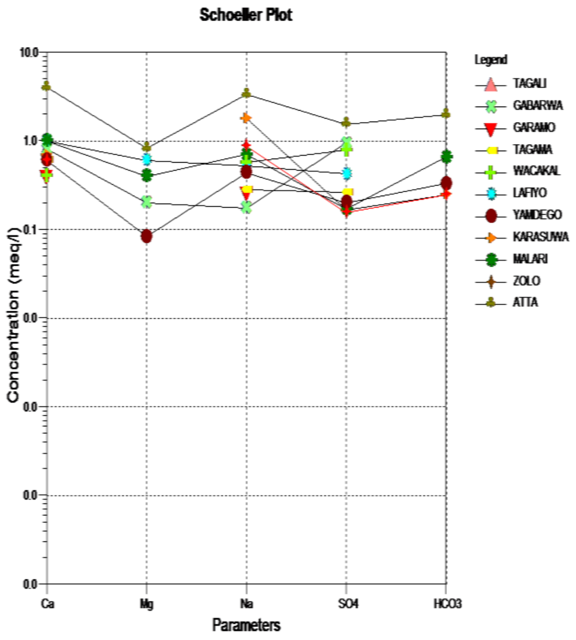

Figure 12: Schoeller plot for data of the wet season

Figure 20 shows plot concentrations in mg/l on y axis against parameters (Ca, Mg, Na, SO_4, HCO_3) on x axis. From the map, the dominant elements that have high concentration are Ca and Hg which are found in Yamdago, Malari and Lafiyo boreholes which are located at the same axis on the map.

Also using Gibbs plot in the study area, figure 21 and 22 indicate that the ionic composition for 19 borehole samples and stream were controlled by three distinct fields such as precipitation dominance, evaporation dominance and rock–water interaction dominance.

Suitability of the water for Irrigation

In terms of Cadmium (Cd) concentration the water can be used for a long term because the measured value ranged from 0.001 to 0.005 mg/l with an average value of 0.003mg/l whereas permissible limit is 0.003 mg/l. For Nikel (Ni) which ranges from 0.005mg/l to 0.394 having an average of 0.199mg/l with a permissible limit of 0.2mg/l can be used for long term irrigation.

Lead (Pb) ranged from 0.378 mg/l to 0.71 mg/l with mean value of 0.544 mg/l whereas the long-term limit is 5.0 and short term is 10mg/l therefore it can be used for long term irrigation. Manganese (Mn) ranged from 0.013 mg/l to 1.297 mg/l with average mean value of 0.650 mg/l whereas the long-term limit is 0.2 and short term is 10mg/l therefore it can be used for short term irrigation. Zinc (Zn) ranged from 0.039 mg/l to 8.622 mg/l with average mean value of 4.336 mg/l whereas the long-term limit is 2.0 and short term is 10mg/l therefore it can be used for short term irrigation. Cupper (Cu) ranged from 0.001 mg/l to 0.098 mg/l with mean value of 0.049 mg/l whereas the long-term limit is 0.2 and short term is 5.0mg/l therefore it can be used for long term irrigation. Iron ($Fe2^{+}$) ranged from 0.21 to 7.0 with an average mean of 3.61mg/l whereas the long-term limit is 5.0 and short term is 20mg/l therefore it can be used for long term irrigation.

4. Conclusion

The study indicated that some of the groundwater and stream samples in the Karasuwa area are generally suitable for irrigation and domestic uses. But not all the borehole are suitable for drinking due to high concentration of Pb, Cd, Mn, Ni, NO_3, $Fe^{2+}$and Zn and Hg above WHO (2001) and NSDWQ(2007). However, pH is slightly acidic to slightly basic. Lead (Pb) is high and therefore not in accordance with permissible limit and is not suitable for drinking. As such it causes kidney failure in the area (Prosan Engineering Company Ltd2014). Presence of this chemicals indicate the source from the domestic waste, house hold activities, waste generated by industries and geological condition such as rock affected by weathering and erosion all of which were transported by Komadugu, Hadeja-Jama'are River into the study area, Garba (2014). Moreover the concentration of TDS is within the permissible limit. The cations, anions and heavy metals are evenly distributed in study area as indicated on the Figures 8, 9 and 10 and represented on Figures 11, 12 and 13.

5. Recommendation

- More data should be generated so as to ascertain the level of concentration of the toxic trace element in the entire Chad basin.
- Hadejia-Jama'are river and Komadugu river to be dredged to allowed the passage of water to lake Chad there by recharging the aquifer of the area, it will lead to dilution of the high concentration of the physiochemical parameters of the area
- All Constructed Dams should be operational so that water will passage through the river and its tributaries to recharge the aquifer of the area
- To remove heavy metals from the area government should apply the following methods reverse osmosis, distillation, ion exchange, activated carbon filtration.
- For those that are affected by the effect of heavy metals, it is recommended that they should drink more purified water, eat more cilantro, add more chlorophyll to the diet, and replace metal fillings with the resin and also by pump action.

References

[1] Abaje, I.B., &Giwa, P.N. (2010). Flood risk assessment and vulnerability in Kafanchan town, Jema'a Local Government Area of Kaduna State, Nigeria. *International Journal of Sustainable Development*, 3(1), 94-100.

[2] Abovbo, A. A., Ayoola E. O &Osahon G.A (1986). Deposition and Structural Style in Chad Basin of Northeastern Nigeria Am. Association in Pet Geol., **70** (12) 1787-1798.

[3] Adamu, S.M. (2016). Declining Static Water Level in the Borno Basin.

[4] Adelana, S.M, Olasehinde P.I., &Vrbka P. (2003). Isotope and geochemical characterization of surface and subsurface waters in the semi-arid Sokoto Basin, Nigeria. *African Journal of Science and Technology*. **4** (2):80-89.

[5] Adelana S.M. (2006). A quantitative estimation of groundwater recharge in parts of the Sokoto Basin, Nigeria Environment. Hydrology.**14** (5):105-119.
[6] Akujieze, C.N., Coker, S.J.L., &Oteze, G.E (2003). Groundwater in Nigeria-a millennium Experience, distribution, Practice, *Problems and solutions Hydrogeology Journal.*, 11: 259-274.
[7] Alagbe, S.A. (2006). Preliminary evaluation of hydrochemistry of the Kalambaina Formation, Sokoto Basin, Nigeria. Environment Geology, 51: 3945
[8] Ali, S. &Orazulike D.M. (2010). Well logs-derived radiogenic heat production in the sediments of the Chad Basin, NE Nigeria. *Journal of Applied Science* 10: 786-800.
[9] Alker, M. (2008). The Lake Chad Basin Aquifer System: a case study for the research project 'Transboundary groundwater management in Africa
[10] Atabey, E. &Atabey, E. (Ed) (2005).Publications of chamber of geology engineers of Turkey. TMMOB, Ankara.
[11] Barber, W. & Jones D.C. (1965). The Geology and Hydrogeology of the Maiduguri area, Borno Province. Geological Survey Niger Bull **27**:1–117.
[12] Boboye, O.A. &Abimbola A.F (2009).*H*ydrocarbon potential of the lithostratigraphic units in Late Cenomanian-Early Paleocene shale, Southwestern Chad Basin. *World Applied Sciences Journal***7** (5):567-573. Cart
[13] Camalt&Tibbits (1963). Water level and artesian pressure of some boreholes in Chad Basin
[14] Carter, J.D., Barber, S.W. Tait, E.A. & Jones, G.P (1963).The Geology of Part of Adamawa, Bauchi and Borno provinces in North-eastern Nigeria. *Bulletin of the Geological Survey*
[15] Domagalsk,i J.L.& Johnson H. (2012). Phosphorus and Groundwater: Establishing links between agricultural use and transport to streams: U.S. Geological Survey Fact Sheet 2012-300, P. 4.
[16] Gibbs A..J. (1970). mechanism controlling world water chemistry sei 170,795-840 cros ref. google scholer
[17] Goni I.B, Yusuf K & Hassan M. (2014). The Declining Middle Zone Aquifer of the Southwestern Chad Basin in the last Millennium IOSR*Journal of Applied Geology and Geophysics*, Volume 2, PP 67-75
[18] Goni I.B. (2006). The challenges of meeting domestic water supply in Nigeria. *Journal.Mineral.Geology*.**42** (1):51-55.
[19] Goni I.B. Fellman E. & Edmunds W.M. (2001).Rainfall geochemistry in the Sahel region of northern Nigeria. Atmos. Environ. **35** (25):4331-4339.
[20] Goni, I.B. (2002). Hydrogeochemical approach to groundwater recharge studies in the Nigerian sector of the Chad Basin. Ph.D thesis, University d'Avignon, 123p.
[21] Goni, I.B., Fellman, E. & Edmunds, W.M. (2001). A Geochemical study of rainfall in the Sahel region of northern Nigeria. Atmospheric Environment, **35**. Pp. 4331-4339.
[22] Hassan S.M. &Tanvar (2008).Assessment of Ground water Evaporation through ground water module with specio temporary variable flusheshealthy male subjects. Br. J. Nutr. **84** (6):865-887.
[23] Joint environmental audit on the drying of Lake Chad (2015). Published in South Africa.
[24] Kessler T. &Hesse A (2000). Cross-over study of the influence of bicarbonate-rich mineral
[25] Kolo B.G, Jibrin M.D, &Ishaku I.N (2009).Elemental analysis of Tap and Borehole water in
[26] Lake Chad Basin Commission (LCBC), (2003). Creation and Extension of the Lake Chad. Lake Chad.Monog. Biol., 53: 11-26.
[27] Lakshmanan E, Kannan R. & Kumar M.S (2003). Major ion chemistry and identification of Hydrogeochemical processes of ground water in a part of Kancheepuram district, Tamil Nadu, India Environ. Geoscience.**10** (4):157-166.
[28] LCBC, (2003). Lake Chad Basin Commission: Vision 2025. Retrieve from: http://www.cblt.org/.
[29] Longe E.O, Malomo S. &Olorunnwo M.A. (1987).Hydrogeology of Lagos metropolis.
[30] Ma'aji, U.M. (2012). A Review of the Aquifer Potentials of the Sedimentary Hydrogeological Province of the Middle Benue Trough within Nassarawa State, North Central Nigeria. M.Sc thesis. Ahmadu Bello University, Zaria.
[31] Macaulay, O. O. (2008), *Revision Notebook on Hydrogeological Practices, with application to Nigerian Groundwater Terrains*. PIOS Publication, Illorin, p. 1-25.
[32] Adamu M.S. (2007)."Groundwater as part of the work of Lake Chad Basin Commission (LCBC)".Lake Chad Basin Commission.
[33] McNeely R.N, Neimanis V.P. & Dwyer L. (1979). Water quality sourcebook: A guide to water quality parameters. Inland Waters Directorate, Water Quality Branch, OttawaMeco services Ltd, pp 1-25
[34] Mediterranean Regions.USGS Water Supply Report, 1757 – 1, 48p.
[35] Nami, B., (2002). Environmental Degradation of the Lake Chad Basin: Implications for Food Security.In: UNEP,
[36] National Population Commissions (NPC). (2006). Provisional 2006 Nigeria Census Results. Abuja, Nigeria.
[37] Ndubisi O.L. (1990). Managing groundwater resources of the Lake Chad Basin in Nigeria.Proceedings, 1st Biannual Natural Hydrology Symposium, pp 429–436
[38] NGSA (2006).Geological and Mineral Resources Map of Yobe State.Nigerian Geological Survey Agency, Federal Republic of Nigeria.Evidence from hydro geochemistry. J. Geol. Soc. 156(2):345-355.*Nigeria*, **30:** 1 – 108
[39] Nolan B.T, Hitt K.J, & Ruddy B.C. (2002).Probability of nitrate contamination of recently recharged groundwater in the conterminous United States.Environment Science.Technology. 36:2138-2145.
[40] NSWQ (2007). Nigeria Standard for drinking water quality Nigeria Industrial standard, approve by Standard Organization of Nigerian Government council ICS 13.0620.15-19
[41] Nwachukwu&Ekkine (2009). Chad formation is the upper most formation consisting of mudstone with traces Sandstone

[42] Nwankwo C.N, Ekine A.S, &Nwosu L.I. (2009).Estimation of the heat flow variation in the Chad Basin Nigeria.*Journal of Applied Science Environmental Management*. 13(1): 73-80.
[43] Obaje N.G, Wehner H, Scheeder G, Abubakar M.B, &Jauro A. (2004). Hydrocarbon Prospectively of Nigeria's inland Basins: from the viewpoint of organic geochemistry and organic petrology. AAPG Bull 87:325–353
[44] Obaje N.G. (2009). Geology and Mineral Resources of Nigeria, Lecture Notes in Earth Science 120, DOI.1007/978-3- 540-92685-6_6, Springer-verlag. Berlin Heidelberg
[45] Odada, E., L. Oyebande, and J. Oguntola. 2006. Lake Chad: experience and lessons learned. Retrieved November 26, 2014, from http://www.worldlakes.org/uploads/06_Lake_Chad_27 February2006.pdf.
[46] Offodile, M.E. (2002). An Approach to Groundwater Study and Development in Nigeria.
[47] Omali, A.O., 2011. Hydrogeological implications of the fast drying up of Lake Chad, Nigeria. *Journal of Environmental Science Resource Management*, 3: 85-93.
[48] Schoeneich, K&Garba M.L. (1998). *Geol. 400 Hydrogeology Lecture Notes* Unpublished, Department of Geology, ABU Zaria.
[49] Prosan Engineering Company Ltd. (2014). The effect of kidney failure in Bade and Nguru Local Government Areas of Yobe State.
[50] Prosan Engineering Company Ltd. (2014),An analysis for lead (pb) around Nguru and Gashua town.
[51] Ramakrishnaiah, C.R, Sadashivaiah C&Ranganna G (2009). Assessment of Water Quality Index for the Groundwater in TumkurTaluk, Karnataka State, India. E-J. Chem. **6** (2):523-530.
[52] Reyment, R. A., &Reyment,E. R., 1980, The Paleocenetrans-Saharan transgression and its ostracod fauna, in Salem, M. J., and Busrewil.
[53] Richards, L.A. (1954). Diagnosis and improvement of saline alkali soils. US Department of Agriculture, Handbook, 60: 160.
[54] Sahinci, A. (1991). Dog˘alSularınJeokimyası (Geochemistry of natural waters). Reform Printing Office, Izmir.
[55] Sanchez *et al*., (2014). Hydrochemistry of Ground Water Quality from Urban wells in Almandin
[56] Schoeneich, K. &Garba M.L. (2010). *Geol. 809 Water quality Lecture note*. Ahmadu Bello University, Zaria.
[57] Schoeneich, *et al*. (2004).Evaluation of Depth to Basement Complex and CenozoicUnconformity from Seismic Profiles and Boreholes in the Nigerian Sector of the Chad Basin.
[58] Wasik, E., Bahdziewic Z.J. &Blasszczyk M. (2001).Removal of nitrates from groundwater by hybrid process of biological Identification and microfiltration membrane.Process Biochemist. 37:57-64. Water on urinary composition in comparison with sodium potassium citrate.
[59] WHO, (World Health Organization) (2006).Guidelines for drinking-water quality. First Addendum to 3rd edition, 1, Recommendation. Geneva, p. 595.
[60] Wolfe, A.H. &Patz J.A (2002). Reactive nitrogen and human health: Acute and long term implications.
[61] World Bank, (2002).Reversal of Land and Water Degradation Trends in the Lake Chad Basin Ecosystem Project Brief.
[62] World Health Organization (2011) Guidelines for drinking water quality (4th edition).