

Variation of Groundwater Parameters through West to East Central Profile Section in Mubi Town, Northeastern Nigeria

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Abstract The study discussed sixteen physico-chemical parameters from thirty three groundwater samples on two dimensional maps along east-west central profile section. The results indicates the water at some points to reflecting the geologic formations through which it travelled, its residence time and man's interaction around some sampling points. Trough-like structures of about 2 mg/L and 4 m/L separate potassium ion concentration value of above 20 mg/L at the western side from those of about 16 mg/L at the central and eastern parts. A systematical rise of sodium ions concentration from the west to the east is attributed to increased domestic activity along the same direction. The low values of nitrate ions at the central part than at the two tails of the profile, the high chromium ions above and, the low sulphate ions below the international accepted limits should be checked at the sampling points they were obtained for accuracy of the analysis and/or sources of the anomalies, so as to offer necessary remedial measures to the communities around such water points.

Keywords: groundwater, formation, ions, profile, parameters

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1. Introduction

Mubi town constitutes part of the crystalline Basement Complex of Northeastern Nigeria. The area lies between Latitude 10°15'00" N - 10°17'00" N and between Longitude 13°14'50" E - 13°17'40" E (Figure 1). Mubi area is characterized by drier climate of semi-arid regions. Annual rainfall lasts for a maximum period of five months and about eighty percent of the rain falls in the months of July and August. During this period of high precipitation, the area is recharged directly through infiltration of rain water and surface water runoff. Drainage pattern over the area consists more or less of braided system of ill-defined streams. The overall drainage pattern is dendritic with extensive areas of braided streams.

Groundwater parameters vary from place to place and from rock to rock as the water travel through geologic formations. Some localities may contain high concentrations of certain parameters and deplete of others. This can be attributed to the availability or otherwise of the chemistry and mineralogy of the source rocks, the path through which the water travel and residence time of the water. Also man's interaction with the environment contributes enormously to variation of some groundwater parameters in some localities.

The exercise was undertaken in the month of June, 2016 with the aim of establishing the variability levels of sixteen parameters in the groundwater samples from Mubi

town on two dimensional maps through west to east central profile (AA') section.

2. Geology of the Study Area

Crystalline rocks of the Basement Complex are widely spread in Africa. In Nigeria, the Basement Complex is the principal and oldest stratigraphic unit and consists mainly of granites, gneisses, migmatites and sub-volcanic schist rocks. It is believed to have undergone through various tectonic events with differing intensities from the Achaean to the Pan African.

The basement region, in which the study area lies is exposed over much of the northern part of Adamawa State and is defined tectonically by fault bounded basins containing Cretaceous to Quaternary sediments. It is bordered at the north by the Chad Basin; to the west and to the south it is delimited by the graben structure of the Benue Trough and the lateral Yola Trough. Migmatite-gneiss, schists, tectonised granitic rocks and undeformed granites of Older Granite suite underlay the study area [1]. The Older Granite is hill forming, outcropping as batholiths. Low-lying migmatite gneisses, schists and quartzites enveloped the batholiths. Late Tertiary volcanic activity in Nigeria gave rise to the Biu Plateau and numerous volcanic plugs and dykes characterized by conical hills and calderas occur in the south towards the Benue Trough. Isolated plugs are preserved along the Mandara mountain chain [2].

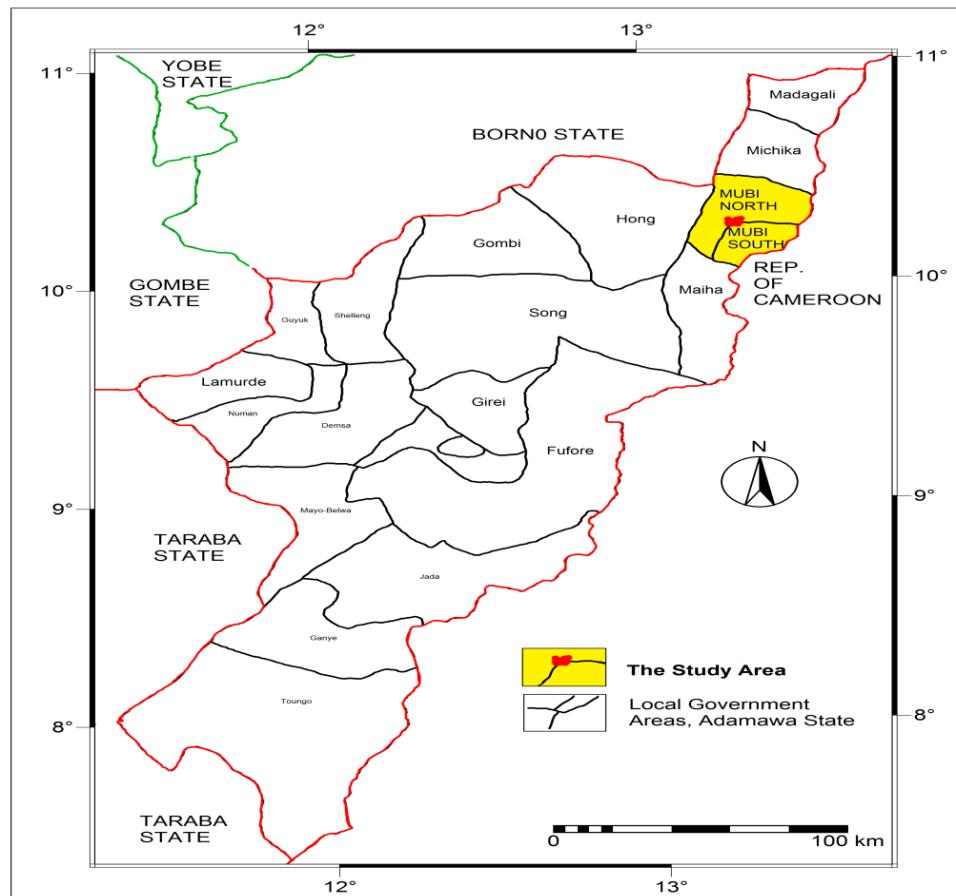


Figure 1. Study area

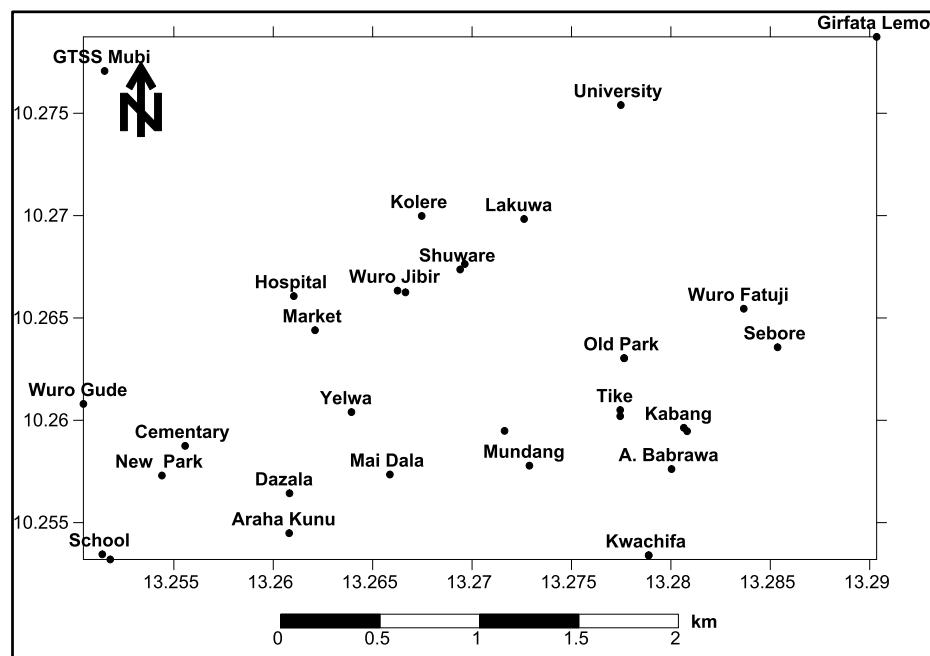


Figure 2. Location of sampling points

3. Materials and Methods

Thirty three groundwater samples were collected and analyzed for their physico-chemical parameters. The samples were collected in clean polythene bottles. The bottles were tightly sealed and labeled in the field. Some water sampling points are shown in Figure 2. Physico-chemical

analysis of the water samples were carried out for pH, electrical conductivity (EC), sodium, potassium, calcium, magnesium, bicarbonate, chloride and sulphate in accordance to standard methods for examination of water and wastewater of American Public Health Association [3]. The pH and EC of the water samples were determined with a Combo pH/EC meter. Sodium, potassium, calcium and magnesium

ions were determined using Perkin Elmer Analyst 400 Atomic Absorption Spectrometer (AAS). The anions of sulphate were determined by Lamda 35 Ultraviolet Visible Spectrometer, and amount of chloride and bicarbonate ions were determined by titration.

4. Results and Discussion

Physico-chemical parameters of the groundwater analyses are presented on two dimensional maps, however, discussion on the parameters are made through the west to east central profile section along latitude 10°15'54" N indicated by profile section AA'.

east central profile section along latitude 10°15'54" N indicated by profile section AA'.

References [4] and [5] recommended pH standards values of 6.5 - 8.5 for drinking water. Where this standard is not obtained, water with pH values from 6.5 - 9.2 may be accepted [6]. Majority of the pH parameters of the groundwater samples through the west to east central profile section in Figure 3 are lower than 8 except around E 13.263° where the value is higher, but less than 8.5. Thus the pH values for the water sample lie within the accepted range, thereby making the water favorable for domestic purposes.

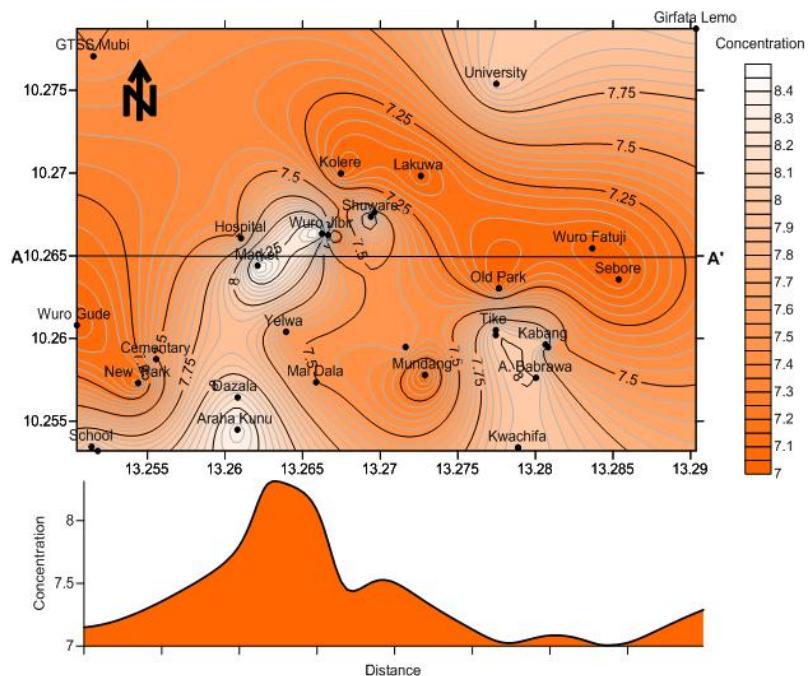


Figure 3. pH

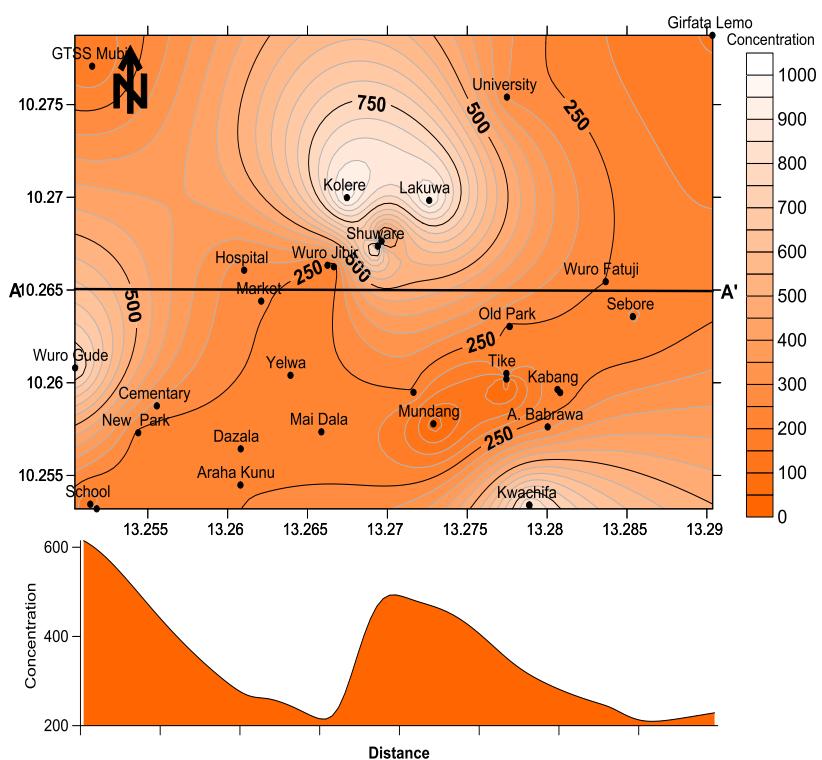


Figure 4. Electrical conductivity

Results of electrical conductivity (EC) data indicate the total quantities of soluble salts in water samples. At any particular location the soluble salts in groundwater depends on its amount, water into which it dissolved, human activity and the geology of the area. In Figure 4, the electrical conductivity values of the water samples range from 200 - 610 mS. Along the west to east central profile section the EC values have two peaks of 610 mg/L and 550 mg/L. These peaks are attributed to increased anthropogenic activities such as discharging of waste materials in the area. Though neither [4] nor [5] provided recommended value for this parameter, however all values are below permissible limits for these organizations.

Total Dissolved Solids (TDS) is the amount of minerals content dissolved in water. High dissolved solids in water may deteriorate domestic plumbing and appliances and also influence health hazards. High TDS may be obtained from shallow aquifer and, variable TDS in the groundwater

in the area could be due to mineral weathering of the rocks and anthropogenic influences of fertilizers in the soil. Total dissolved solids values shown in Figure 5 through the west to east central profile range from 1389 - 1762. These values are acceptable for several purposes.

Standard limit for bicarbonate in drinking water is 500 mg/L; beyond which the taste of water becomes unpleasant. In the absence of an alternative source, a bicarbonate value up to 1000 mg/L may be tolerated. Bicarbonate ion concentration value above 160 mg/L around longitude 13.283° E is observed through the west to east central profile, while the lowest value which is slightly above 120 mg/L is around longitude 13.261° E (Figure 6). Most of the highly concentrated bicarbonate ions were observed around the eastern half of the profile. Since the level of the bicarbonate ions is lower than the required limit, groundwater along the profile is safe for drinking.

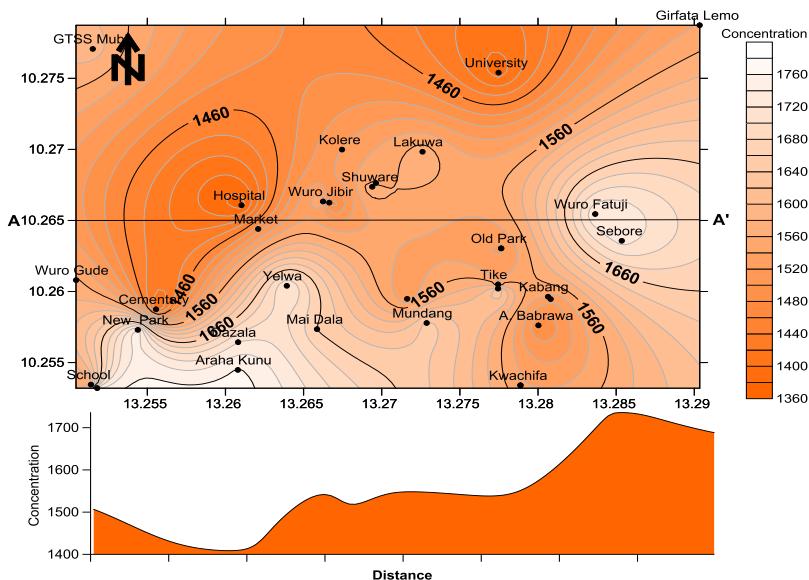


Figure 5. Total dissolved solutes

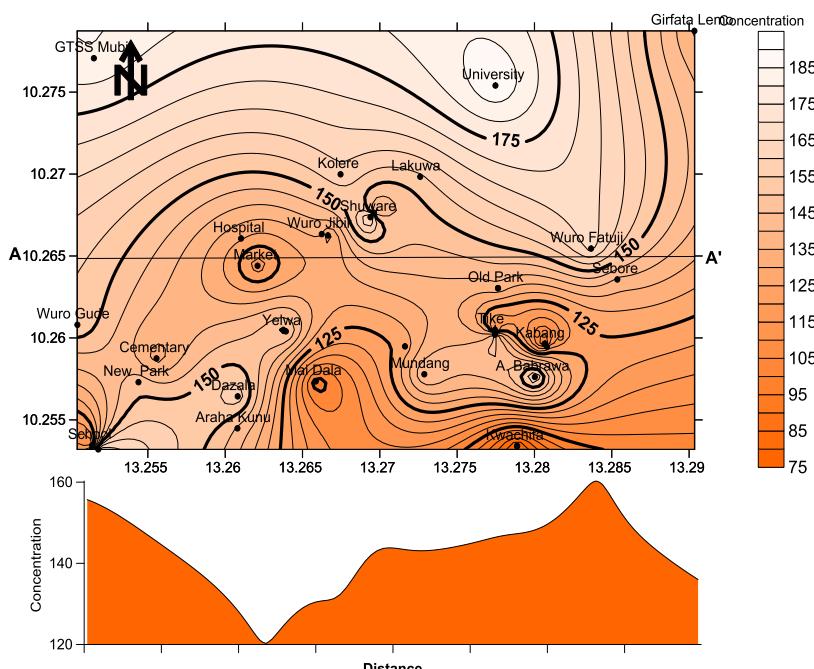


Figure 6. Bicarbonate

Large quantity of calcium in water contributes greatly to the hardness of the water. Reference [4] recommended ions concentration values of 75 mg/L, while the acceptable limit by [5] is 75 mg/L. If these requirements are lacking, [4] and [5] each permitted maximum concentration value of 200 mg/L. Figure 7 shows the variation of calcium ions in the groundwater. The groundwater system along the profile has calcium ions concentration level peak at slightly above 40 mg/L. Concentration as low as 30 mg/L was obtained towards the eastern axis of the profile. Since concentration of the

ions is below the permissible limits, the calcium in the groundwater may be useful for several purposes.

In most instances chloride is readily leached by dissolution of sodium chloride through human activity. Accepted limit of chloride ions in portable water is 200 mg/L by [4] and 250 mg/L by [5] and permissible standards are 500 mg/L by [4] and 600 mg/L by [5]. Chloride ions concentrations in the groundwater samples in Figure 8 vary from 2 - 27 mg/L The low range of chloride ions in the groundwater system along section AA indicates low level of human activity in the area.

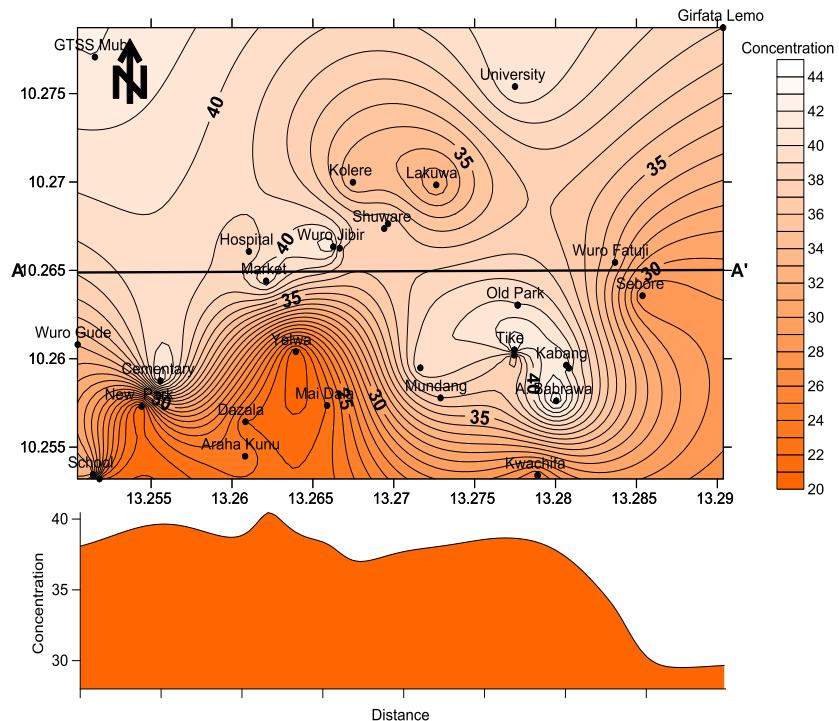


Figure 7. Calcium

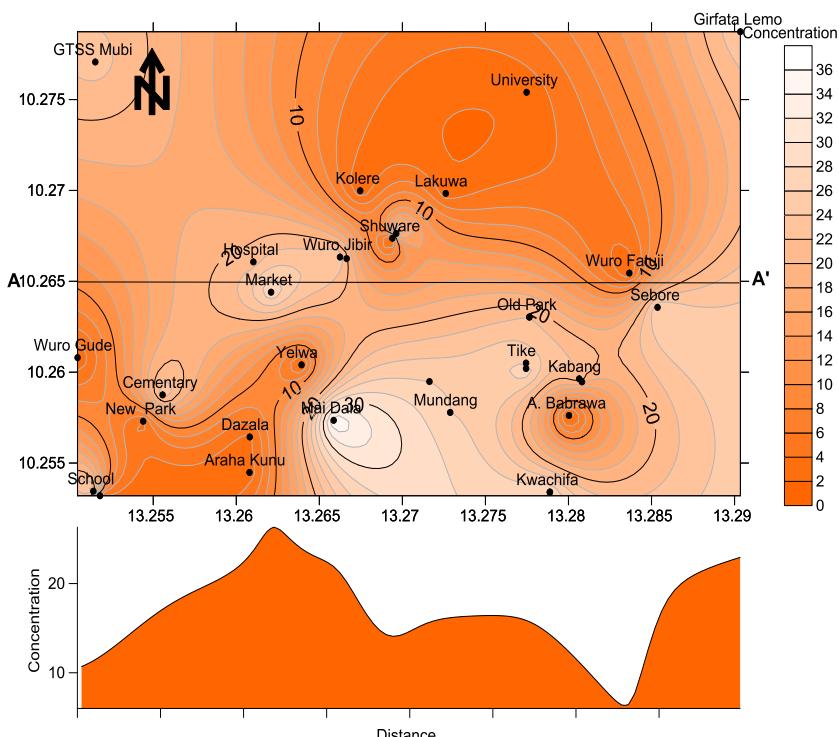


Figure 8. Chloride

Occurrences of chromium in unpolluted ground waters are extremely low [7]. The maximum permissible limit for chromium ions is 0.05 mg/L. The highest value of chromium is 0.08 mg/L and the lowest value is 0.01 mg/L through the west to east central profile. Concentration of chromium ions above the standard concentration limit along the profile in [Figure 9](#) clearly indicates that the groundwater chemistry at some points has been impacted by anthropogenic impurities, thereby rendering it less useable. The possible sources of the chromium ions in the water samples may be attributed to contaminants from dyes and point pigments, and metal in ore deposits. According to [8], copper has an affinity and a similar geochemistry with chromium and both are dispersed in solution and concentrated under favorable conditions ...delete.

According to [8], copper has affinity and similar geochemistry with chromium and both are dispersed in

solution and concentrated under favorable conditions like local physiographic conditions and other coalescing factors. It occurs as particulate matters and in rocks. The presence of copper in the water samples above the required limit can cause gastro intestinal bleeding, haematurial intravascular haemolysis, methaeglobinaemia and acute renal failure etc. Occurrences of copper in unpolluted ground waters are extremely low [7]. The maximum permissible limit for copper is 1 mg/L. The highest value of copper ions in [Figure 10](#) is 0.18 mg/L and the lowest value is 0.01 mg/L. These results are lower than the standard limits, which explains low impact of anthropogenic impurities in the groundwater chemistry along the profile and is useable for different functions. Uniformity in the concentration level of copper in the area suggests similarity in the source materials.

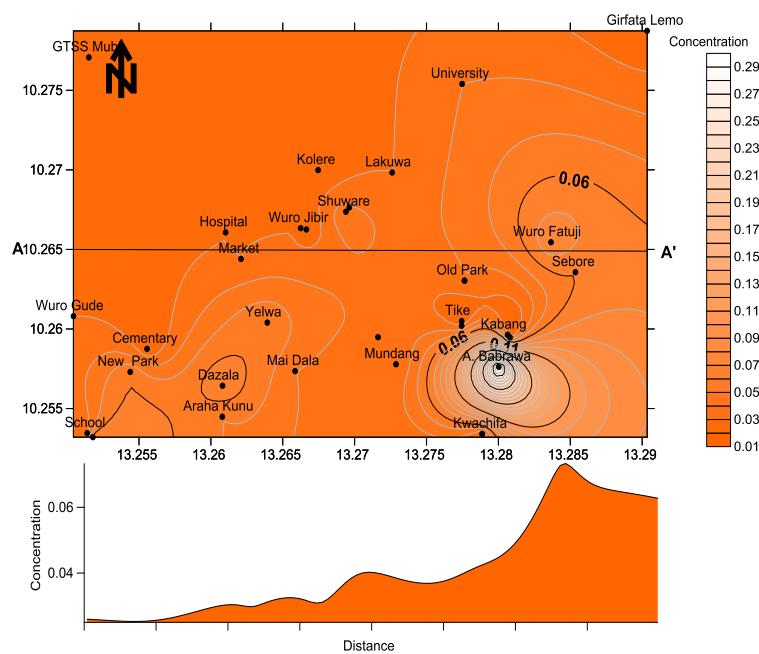


Figure 9. Chromium

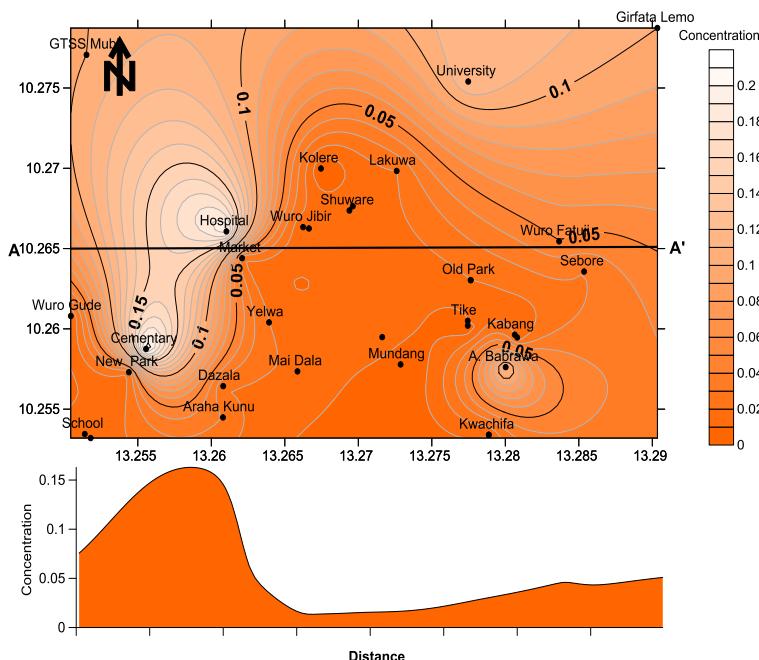


Figure 10. Copper

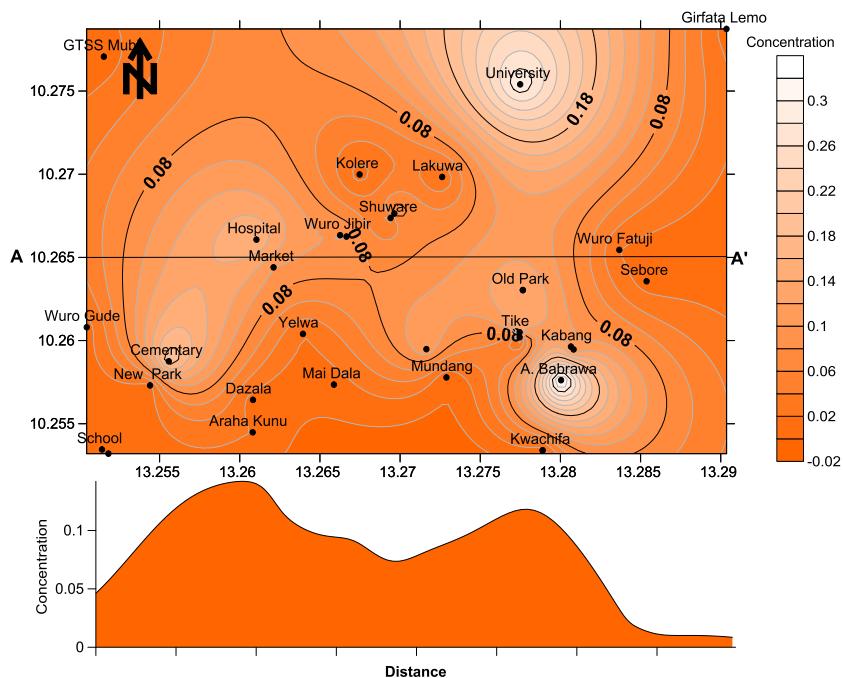


Figure 11. Iron

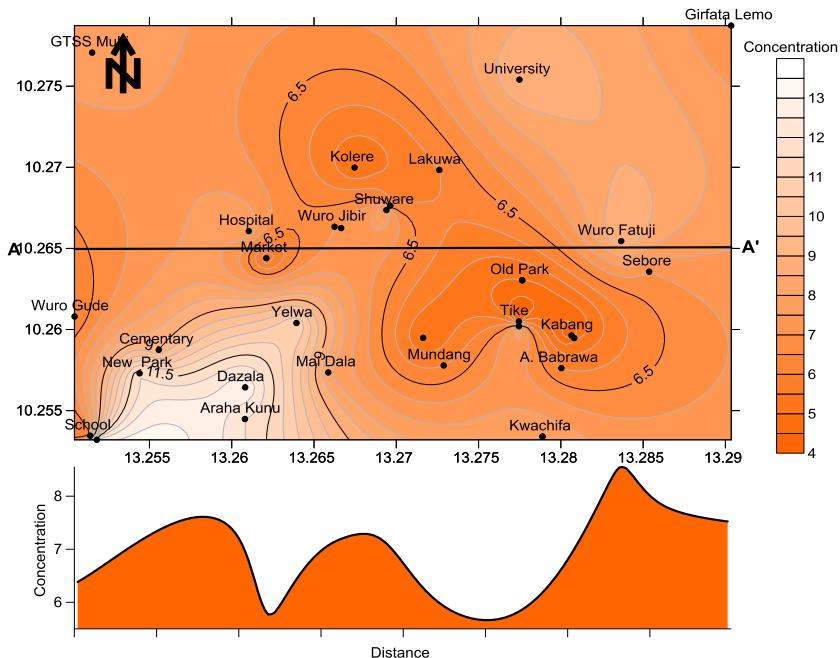


Figure 12. Magnesium

Iron occurs in water in its ferric and ferrous states particularly in well aerated conditions. It occurs also in rocks and minerals dissolution, acid mine drainage, land fill leachates, sewage and iron related industries. Chemical behavior of iron and its solubility in water depend strongly on the oxidation intensity in the system in which it occurs; pH is a strong influence also. Iron if present in water in excess forms red oxy-hydroxide precipitates that stain laundry and plumbing fixtures and therefore is an objectionable impurity in domestic and industrial water supplies. When the material is attacked by water the iron that may be released is re-precipitated nearby as sedimentary species. Reference [9] reported 0.3 mg/L as the upper recommended limit of iron in public water supplies. In Figure 11 the highest concentration along the

profile is 0.13 mg/L while the lowest is about 0.01 mg/L. This range is below the limit of 0.3 mg/L given by [10], hence making the iron favorable for numerous usages. The source of the iron in the area is weathered overburden which, at some points, dissolved in the water in contact with laterite. Weathered amphiboles, magnetite, biotite, garnet and mafic minerals in the rocks might have further enriched the concentration of iron in water.

The groundwater system from Mubi through the west to east central profile has its magnesium concentration level peak at slightly above 8 mg/L (Figure 12). Magnesium ions concentration as low as 2 mg/L was obtained towards the eastern end of the profile. Magnesium plays significant roles in water as its presence in large quantity contributes greatly to the hardness of the water. Reference [4]

recommended concentration values of 39 mg/L for magnesium ions, while an acceptable limit by [5] is 20 mg/L. In the absence of these requirements, [4] and [5] both permitted maximum concentration values of 150 mg/L. Because the 8 mg/L in Figure 12 is below the [4] and [5] recommended concentration values for magnesium ions, the groundwater through the west to east central profile is thus suitable for all functions.

Manganese plays significant roles in geochemical environment and portability assessment of water [11]. Manganese in groundwater originates from weathering of rock fragments and in unconsolidated deposits through oxidation/dissolution of the underlying bedrock [12]. Manganese occurs in clay minerals as manganese hydroxides and is leached under anaerobic conditions. The standard limit of manganese as reported by [10] is

0.2 mg/L, however, in groundwater it could be greater than 1.0 mg/L under some circumstances. The concentration of manganese ions along the profile of Figure 13 ranges from 0.002 mg/L – 0.017 mg/L. Thus its present quantity along the profile may not provide any objectionable taste.

Nitrate parameter has two peaks (Figure 14). The western peak (around E 13.252°) has concentration value below 3 mg/L and the eastern peak (around E 13.284°) is above 3 mg/L. Minimum nitrate ions concentration along the profile section is between E 13.26° and E 13.267°. Nitrate ions concentrations below 1 mg/L and slightly above 1.2 mg/L were observed along the profile distances of E 13.271° and E 13.276° respectively. Thus the central part seems to be the domain for lower values of nitrate ions than the two tails of the profile.

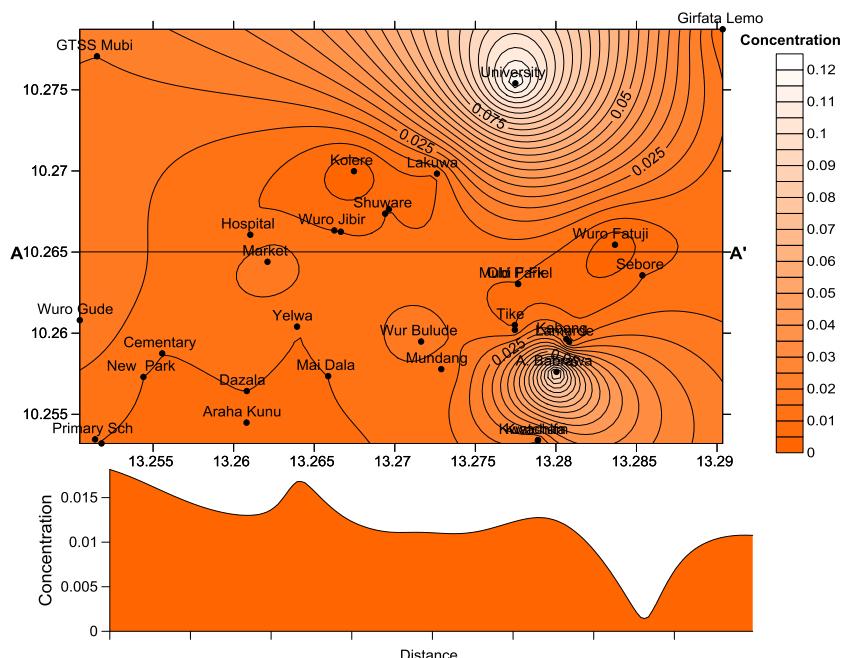


Figure 13. Manganese

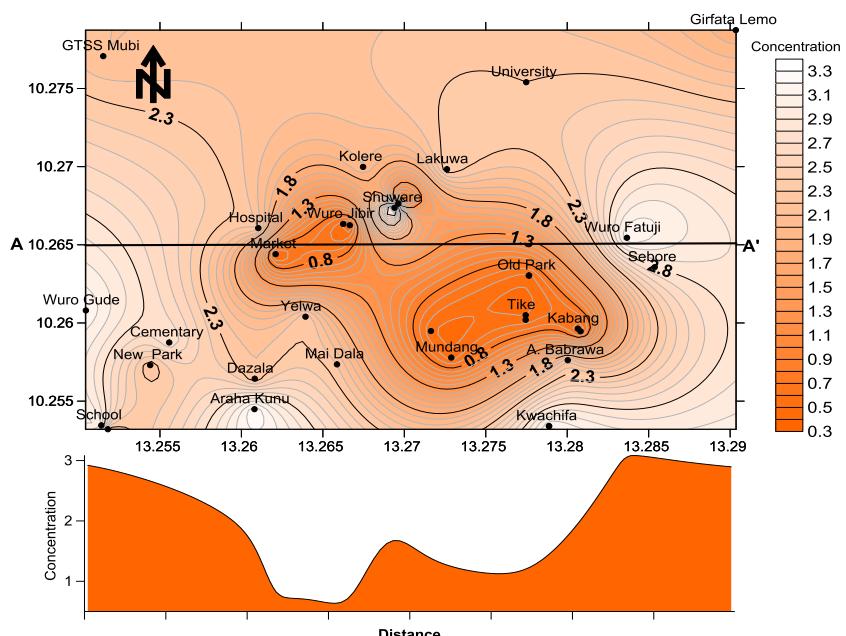


Figure 14. Nitrate

Concentration of potassium ions in the groundwater system along the profile line is over 20 mg/L at the western side and about 16 mg/L at the central and eastern parts ([Figure 15](#)). These high values are separated by two trough-like structures of about 2 mg/L and 4 mg/L. Reference [[13](#)] reported concentration ranges of potassium ions in groundwater of Bama and Konduga areas between 1.44 – 16.60 mg/L and between 1.06 – 12.40 mg/L respectively. Since majority of the ions in the groundwater lies within the ranges of [[13](#)], the water may be considered suitable for several purposes. The over 20 mg/L potassium

ions concentration at the western side needs to be checked for source causes and experimental errors.

Concentration levels of phosphate ions through the west to east central profile in [Figure 16](#) are more or less similar. Exception to this are those ions between E 13.500° and E 13.270°, where the concentration drops to about 0.2 mg/L. The highest ionic concentration of phosphate recorded within the profile is about 0.6 mg/L. Similarity in the concentration of the ions along the profile may be ascribed to similar mineral and chemical compositions of the rock bodies through the central profile section.

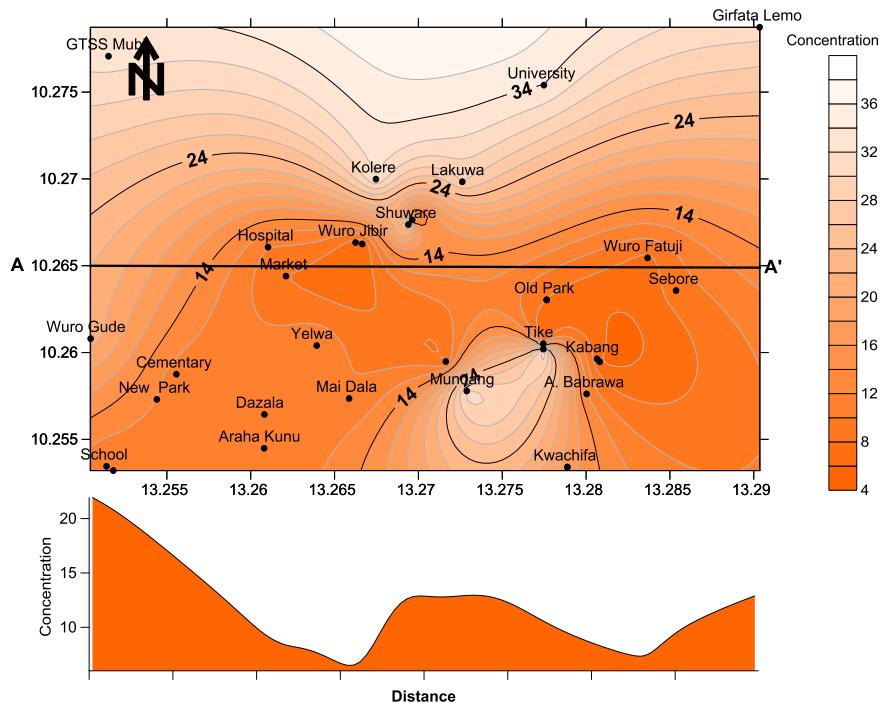


Figure 15. Potassium

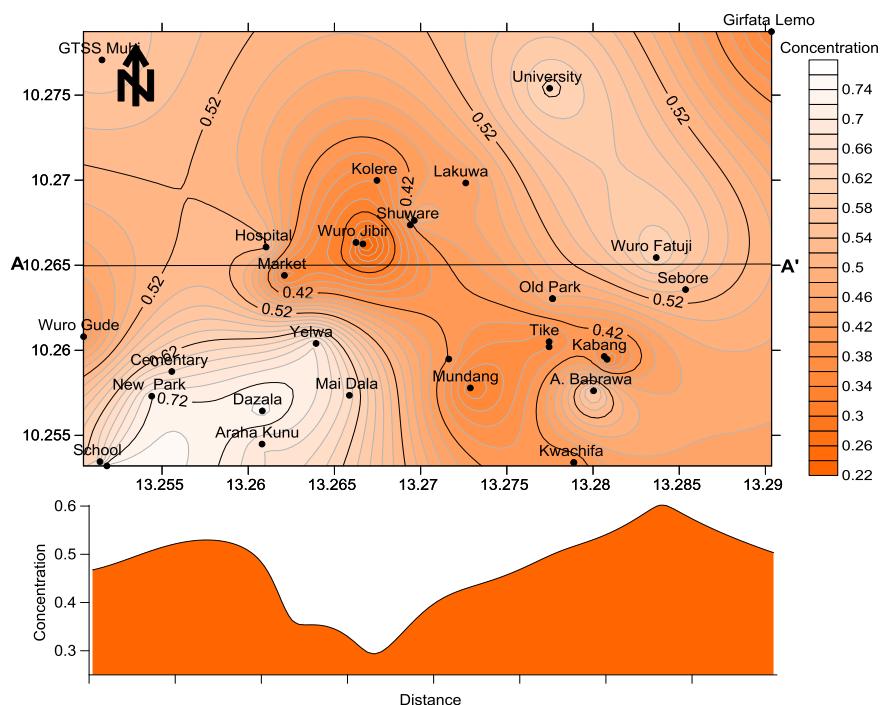


Figure 16. Phosphate

Sodium ion concentration in excess of 150 mg/L makes the water unsuitable for domestic activity and causes severe health problems. In Figure 17 there is a systematical rising trend of sodium ions concentration from the western side to the eastern side of the profile, except at around E 13.260° where this trending pattern was slightly disturbed. Sodium ions concentration values of about 12 mg/L and 22.5 mg/L are the respective minimum and maximum values along the profile. These experimental concentration values are consistent with the ranges of 19.44 - 85.60 mg/L and 7.80 – 72.80 mg/L in the water samples from Bama and Konduga areas respectively given by [13]. Thus the water samples along the profile may be considered acceptable for domestic uses.

Reference [4] recommended and permitted values of 150 mg/L and 250 mg/L respectively for sulphate concentration in water. In Nigeria situation, [5] values of 100 mg/L and 200 mg/L are the recommended and

permissible limits respectively. In Bama and Konduga areas [13] respective sulphate ions ranges are between 0.00 - 31.00 mg/L and 1.38 – 82.52 mg/l.

Sulphate content higher than the permissible limit is unacceptable for domestic purpose as it is likely to cause gastro-intestinal irritation particularly when magnesium and sodium are present in the groundwater system. Water containing sulphate beyond 1,000 mg/L has purgative effects. Sulphate undergoes transformation to sulphur and sulphur oxides depending upon the redox potential of the water. This study obtained the highest sulphate ions concentration of about 24 mg/L at the western side and the lowest value of about 12.5 mg/L around E13.265° (see Figure 18). These values compare favorably with those in [13], but are far below the [4] and [5] recommended values in water. Hence the water samples along the profile should be checked for accuracy of analysis and possible cause of its depletion.

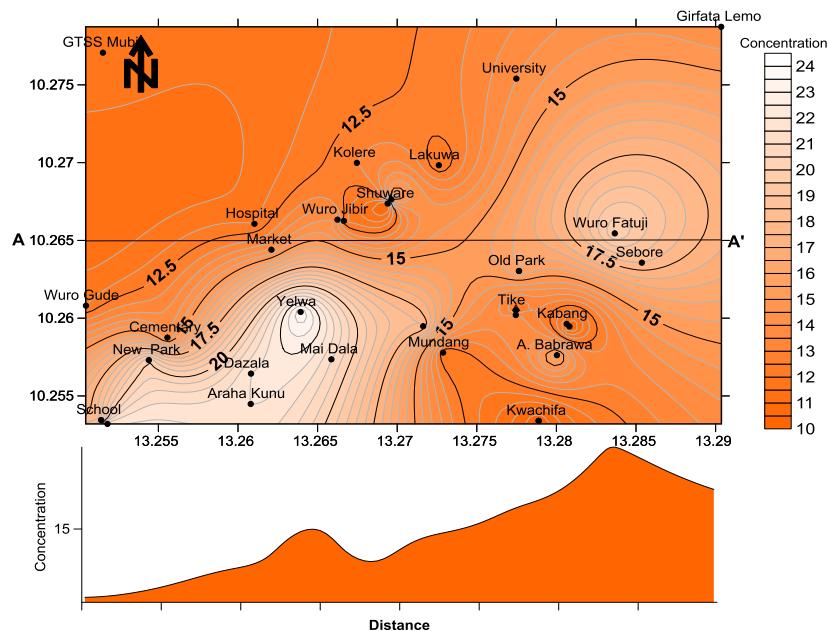


Figure 17. Sodium

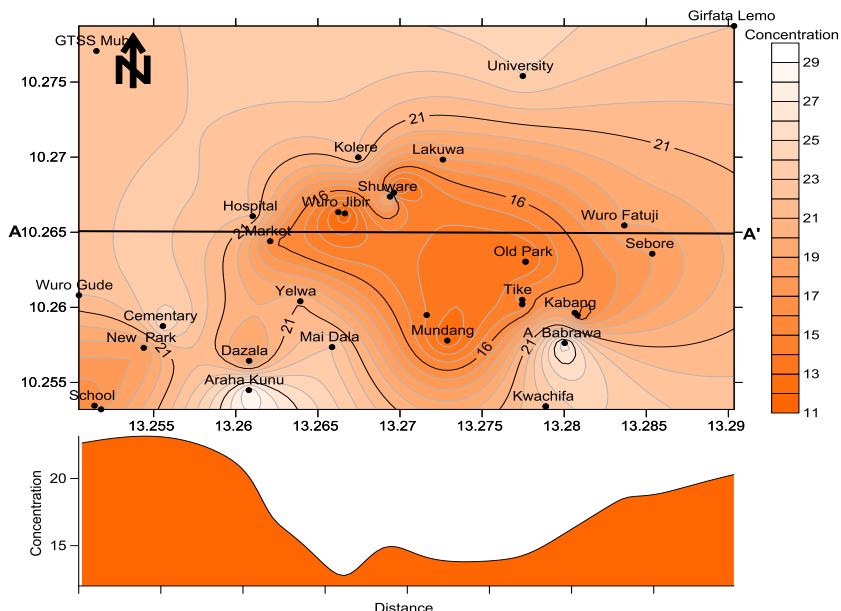


Figure 18. Sulphate

5. Conclusion

Thirty three groundwater samples were collected and analyzed for their physico-chemical parameters. Sixteen parameters were determined, presented on two dimensional maps, and discussed through west to east central profile section AA'. Results of the physico-chemical analysis show that groundwater parameters in Mubi vary from place to place and from rock to rock as the water travel through geologic formations. Some points contain higher concentrations of certain parameters and deplete of others due to the chemistry and mineralogy of the source rocks, the path through which the water travelled, residence time of the water and human's interaction with the environment. Higher chromium ions concentration than the accepted limits at some points show that such points might have been contaminated with dyes, point pigments or metallic ores. The highest sulphate ions concentration of about 24 mg/L is far below the [4] and [5] recommended values, but fits well within the ranges of [13]. This anomaly should be checked alongside those of chromium ions at their respective sampling points for accuracy of the analysis and/or sources of the anomalies, so as to offer possible remedial measures to the communities around the water points.

References

- [1] Conred Nigeria Ltd. "Geophysical Investigation of Agapalawa Area". *Borno State Water Board, Maiduguri, Unpublished report*, 23, 1978.
- [2] Carter, J.D., Barber, W., Tait, E.A. and Jones, G.P. "The Geology of parts of Adamawa, Bauchi and Bornu Provinces in Northeastern Nigeria". *Bull. Geol. Surv. Nigeria*, 30, 109, 1963.
- [3] American Public Health Association. "Standard Methods for Analysis of Water and Waste Water". *American Public Health Association, Inc, Washington DC.*, 1992
- [4] World Health Organization. "Guidelines for Drinking Water Quality". *International Standard for Drinking Water, 1. Geneva*. 130, 2004.
- [5] Standard Organization of Nigeria. "Nigeria Standards for Drinking Water Quality, 17". *National Academy of Sciences*, 594, 2007.
- [6] Singh, S., Singh, P., Kumar, R. and Saharan, S. "Groundwater Quality Analysis of Safidion and Julana Blocks of District Jind, Haryana, India". *Journal of Water Resources and Protection*, 4, 39-47, 2012.
- [7] Mohammed, Y. and Yusuf, A.K. "Bacteriological and Heavy Metals Concentration of Shallow Groundwater Resources in Maiduguri, North-East Nigeria" *Nigerian Journal of Hydrological Sciences*, 5, 5-20, 2017.
- [8] Hem, J.D. "Study and interpretation of the Chemical Characteristics of Natural Water". *U.S Geological Survey Water Supply*, 2254, 1985.
- [9] National Academy of Sciences – National Academy of Engineering. Water Quality Criteria, 1972.
- [10] Nigerian Standard for Drinking Water Quality. "Guidelines for Drinking Water Quality, 1". *Recommendation, Geneva*, 2007.
- [11] Edmunds, W.M. "Geochemical Framework for Water Quality Studies in Sub-Saharan Africa". *Jour. of African Earth Sciences*, 22(4), 1966.
- [12] Mohammed, Y. "Analysis of the Physicochemical and Bacteriological Properties of Groundwater in Maiduguri, Borno State, Nigeria". *M.Sc. Dissertation (unpublished) Department of Geography, University of Maiduguri*, 27, 2015.
- [13] Alkali, S.C. "Groundwater Chemistry from Bama and Konduga Local Government Areas, Northeastern Nigeria" *Global Advanced Research Journal of Physical and Applied Sciences*, 4 (1) 072-079, Sept. 2015.