SSRG International Journal of Applied Physics
ISSN: 2350 – 0301 /doi:10.14445/23500301/ IJAP-V7I3P113

Volume 7 Issue 3, 83-87, Sep-Dec 2020

The Physiochemical Investigation of Groundwater around Jere, North-eastern Nigeria

Tijjani Inusa Atom[1], Muhammad Hassan[1,2,] and Mohammed Maina[3]

[1]*Department of Physics, Faculty of Science, University of Maiduguri, P. M. B. 1069, Maiduguri – Nigeria*
[2]*Centre for Nuclear Energy Research and Training (CNERT), University of Maiduguri, Maiduguri – Nigeria*
[3]*Department of Science Laboratory Technology, Ramat Polytechnic, Maiduguri, Nigeria*

Abstract *- The data on groundwater conditions are needed to encourage the communities on sustainable groundwater management. In this work, the physiochemical investigation was conducted in twenty (20) water samples collected from boreholes, wash boreholes, and hand-dug wells. The direct reading (DR) spectrometer was used to measure the temperature, color, turbidity, P^H, electrical conductivity (EC), cations, and anions. The results obtained from the analysis of water samples showed that TDS of water has a mean of 131.60 mg/l, water has the mean P^H values of 6.94 and the mean EC of the water samples is 373.50 µS/cm. For the presence of cations in the groundwater samples, calcium ion (Ca^{2+}) has the mean concentration of 48.89 mg/l, magnesium ion (Mg^{2+}) has the mean concentration of 5.28 mg/l, potassium ion (K^{2+}) has a mean concentration of 11.10 mg/l and the mean concentration of 0.16 mg/l was recorded for iron (Fe^{2+}). There were also anions present in the water samples and chloride ion (Cl^-) concentration in the sample is 2.73 mg/l, sulfate (SO_4^{2-}) has a mean concentration of 11.90 mg/l and the values of fluoride ion (F^-) concentration in the water sample is 0.15 mg/l. Thus, the mean cations concentration level of the groundwater sample collected from the Muna area are in the sequence of $Ca^{2+} > Mg^{2+} > K^+ > Fe^{2+}$ while the mean anions concentration level has the sequence $SO_4^{2-} > NO_3^{2-} > Cl^- > F^-$. These values, when compared with the WHO (2011) and SON (2007) standards are found to be within the recommended and permissible limits.*

Keywords — *Physiochemical, groundwater, assessment, cations, anions, Jere.*

I. INTRODUCTION

Water is the most important ingredient for life on Earth after oxygen, it is essential for drinking, domestic uses, and even the pattern of human settlement has often been determined by the availability of water [1,2]. The importance of water cannot be overemphasized. Water plays an important role in the world economy, as it functions as a solvent for a wide variety of chemical substances, industrial cooling, transportation, and agriculture. However, the quality of drinking has to meet standards to be safe for human consumption. About 33% of people on earth, lack access to safe drinking water and about 40% do not have access to adequate sanitation service [3]. Freshwater that is available for human consumption comes from rivers, lakes, and subsurface aquifers and has been characterized with problems ranging from contamination by heavy metals and other chemicals which their exposure cause harmful effect to human, to inadequate information to facilitate its exploitation for use [4,5]. Contaminants such as Bactria, heavy metals, nitrates, and salt have found their way into water supplies due to inadequate treatment and disposal of waste from humans and livestock and overuse of limited water resources [6]. Studies had been carried out to ascertain the quality of drinking water, mainly by determining heavy metals present [7].

However, water and its quality should meet domestic standards for portable water supply [8]. Water levels in boreholes have fallen and boreholes yield have drastically declined [9]. Indeed, water resources have always been the primary concern of the communities especially in the study area and its environs which have been persistently affected by insurgency and influx of internally displaced persons (IDPs). Hence the reasons for getting adequate and improve the sustainable supply of water is generally becoming more and more concern due to ever-increasing population and agricultural activities, with an increasing effort from non-governmental organizations (NGOs) in constructing and rehabilitating existing water points in and around the study areas. Muna and its environs occupy a vital position in Jere local government area, Borno state. It serves as a commercial and residential area for a large number of people and also the rearing of animals. These resulted in the sitting for boreholes, hand-dug pumps or wells, etc. leading to the stressing of the aquifers, due to abstraction. If abstraction happens the flow of the water, as well as the quality of the water for human and other purposes, may be affected. Groundwater is a predominant, strategic, and most reliable source of water supply for domestic, agriculture, and industrial usage in the Muna area, Jere local government area, Borno State, and the country as a whole. Therefore, this study aimed to investigate the physiochemical parameters of groundwater around the Muna area. Muna is located in Jere local government area, it falls between latitude 11^0 53 56"8 North and longitude 13^0 17 29"6 East. The area has two seasons, namely dry and raining seasons. The temperature is generally high with a mean annual value of about 32 °C.

II. METHODOLOGY

The geochemical method utilized the use of direct reading (DR) spectrophotometer in the determination of physicochemical parameters of the water samples collected in the existing boreholes, wash boreholes, and hand-dug wells by using clean bottles at the same points of investigations. The P^H, color, Electrical conductivity (EC), Total dissolved solids (TDS), Temperature, Cations, and Anions were determined and analyzed by using standard methods of using the DR spectrophotometer. The procedure involves diluting the water samples, set the time, but the sample in the DR-spectrophotometer, and press read to display the results to assess and determine the quality of the water. The P^H and temperature were measured with a P^H meter (Model HI 98129), EC, TDS was measured with a combo portable conductivity-meter. The DR spectrophotometer, other equipments, and materials used in the investigations, analysis, and determination of physicochemical parameters have been very popular and prove to be very effective in groundwater studies and found to be extremely successful.

III. RESULTS AND CONCLUSIONS

The results for the physical and chemical composition obtained from this study are presented in Table 1. It can be seen from Table 1 that the temperatures vary from 34 °*C* to 28 °*C*, with a mean value of 31.4 °*C*. The high-temperature condition may not be desirable for water samples as it encourages the growth of microorganisms, which have the potential of altering the color, odor, taste, etc of the water. According to Stun and Morgan, (1981), temperatures higher than the background level of 22 °*C* to 29 °*C* are for water in the tropics. Hence, the recommend and permissible limit values for both WHO (2011) and SON (2007) are 25 °*C* and 30 °*C* [10-12].

The Recommended turbidity values are given by both WHO (2011) and SON (2007) for drinking water are 5.00 *NTU*. The result obtained from this study (Table 1) showed that the turbidity of water in Jere ranges from 0.50 *NTU* to 2.10 *NTU*. Turbidity in the water sample is caused by suspended and the presence of particulate matter.

The TDS range from 102 *mg/l* to 180 *mg/l* (Table 1) and it has a mean of 131.6 *mg/l*. The recommended value by WHO (2011) is 500 *mg/l*, therefore, all the values obtained from the study area are below the recommended limit for these organizations. The low TDS value was due to the continuous recharge of the groundwater from rainfall. It was suggested that such situations combining resistivity data with in situ TDS are naturally from shallow aquifer [13].

Table 1 showed that the P^H values of water samples range from 6.43 to 7.20 with a mean of 6.94. Thus, the P^H distribution shows that the groundwater in the Muna area is acidic. The recommended and permissible standard P^H values of water given by WHO (2011) and SON (2007) are 6.5 and 8.5, and 5.5 and 8.5 and respectively. The P^H value is within the tolerable limit by WHO and SON. Where there is no alternative source, water with a P^H value from 6.5 to 9.2 may be accepted [14] and a low P^H cause corrosion of water carrying metal pipes, thereby releasing toxic metals such as zinc, lead, and copper [15].

The EC values presented in Table 1 range from 97.0 to 656 $\mu S/cm$, with an average value of 373.5 $\mu S/cm$. The permissible limits are given by WHO (2011) and SON (2007) is 1450 $\mu S/cm$ and 1000 $\mu S/cm$ respectively. All these values are below the permissible limit provided by the organizations. However the low EC value indicates a low degree of mineralization and input from the agricultural activities, but the water quality is good and safe for drinking and domestic purpose.

Table 1: Physicochemical composition of Muna groundwater

Sample ID.	T (°C)	Color	Turbidity	TDS (*mg/l*)	pH	EC ($\mu S/cm$)
MNK 1	28	1	0.97	129	6.46	97.0
MNK 2	30	1	0.96	128	7.20	628
MNK 3	31	0	0.60	174	7.18	611
MNP 4	32	0	0.65	140	7.24	451
MNP 5	32	0	2.00	162	7.23	620
MNM 6	32	0	0.50	179	7.01	549
MNM 7	32	1	0.62	115	7.20	310
MNF 8	28	1	2.10	133	6.98	407
MNF 9	30	0	0.98	175	6.87	373
MNF 10	32	0	0.99	142	6.78	332
MNE 11	33	0	0.51	164	6.99	372
MNE 12	32	1	0.58	180	7.02	331
MNKR 13	32	0	0.60	127	6.89	271
MNKR 14	30	0	0.61	102	6.43	223
MNKR 15	32	1	0.63	102	6.71	214
MNG 16	32	1	0.64	116	7.02	301
MNGS 17	32	0	0.66	132	7.08	343
MNC 18	32	1	0.51	130	6.87	656
MNC 19	34	0	0.56	131	6.54	166
MNC 20	32	1	0.55	130	7.01	216
Minimum values	28	0	0.50	102	6.43	97.0
Maximum Values	34	1	2.10	180	7.24	656
Mean	31.4	0.45	0.811	131.6	6.94	373.6
Range	6.0	1.0	1.6	78	0.81	559

Table 2 showed the physiochemical composition of Muna groundwater. For cations in the groundwater system of the study area, the maximum and minimum concentration values of 136.0 *mg/l* and 4.80 *mg/l* respectively were recorded for calcium (Ca^{2+}), with the mean value of 48.89 *mg/l*. Magnesium (Mg^{2+}) recorded the highest and lowest concentration values of 16.30 *mg/l* and 1.22 *mg/l* respectively and a mean concentration of 5.28 *mg/l* was recorded. Calcium and magnesium play a vital role in the groundwater system as their presence in large quantities contributes to the total hardness of the water. Hence WHO (2011) and SON (2007) recommended the concentration values of 75 *mg/l* and 39 *mg/l* for Ca^{2+} and Mg^{2+} respectively and a permissible concentration value are respectively 200 *mg/l* and 150 *mg/l* respectively. Potassium (K^{2+}) has a concentration ranging from 8.30 *mg/l* to 14.8 *mg/l*, with a mean concentration of 11.1 *mg/l*. For iron (Fe^{2+}) its concentration ranges from 0.10 *mg/l* and 0.24 *mg/l* and the average concentration of 0.16 *mg/l* was recorded. The recommended values are given by WHO (2011) and SON (2007) are 0.3 *mg/l* and permissible limit concentration values of 1.0 *mg/l* and 5.0 *mg/l* respectively. Hence, the groundwater system from the Muna area is within the acceptable limit recommended by WHO (2011) and SON (2007). Nevertheless, the major cations Ca^{2+}, Mg^{2+}, $K^{+,}$ and Fe^{2+} are among the elements essential for human health metabolism.

For the preference of anions, chloride (Cl^-), sulfate (SO_4^{2-}), nitrate (NO_3^{2-}), and fluoride (F^-) was also recorded in the samples. Table 2 showed that the chloride (Cl^-) concentration in the groundwater sample collected from Muna has a maximum value of 8.80 *mg/l* and a minimum value of 1.21 *mg/l*. The minimum recommends a limit of chloride ion given by WHO (2011) is 200 *mg/l* while SON (2007) gives 50 *mg/l* and the given permissible limits are 500 *mg/l* and 600 *mg/l* for WHO (2011) and SON (2007) respectively. Sulfate (SO_4^{2-}) has the lowest concentration value of 0.28 *mg/l* and the highest value of 49.8 *mg/l* with the average concentration values of 11.9 *mg/*. WHO (2011) and SON (2007) have the recommended concentration of SO_4^{2-} 150 *mg/l* and 250 *mg/l* and the permissible concentration of SO_4^{2-} are 100 *mg/l* and 200 *mg/l* respectively. And for nitrate ($N0_3^{2-}$), the variation of concentration levels is ranging from 1.58 *mg/l* to 10.1 *mg/l*, with a mean value of 3.88 *mg/l*. Both WHO (2011) and SON (2007) have recommended and permissible limit concentration levels of 45 *mg/l* and 50 *mg/l* respectively. The level of nitrates in groundwater is of significant importance, particularly in drinking water. It was suggested that high-level exposure to nitrate in drinking water may have adverse effects on the cardiovascular system, nitrate may also cause bacteria and color the teeth brownish if it is found to be above the recommended value given by WHO (2011) and SON (2007) [16]. The values of fluoride in the water sample range from 0.10 *mg/l* to 0.18 *mg/l* with a mean value of 0.15 *mg/l*. For fluoride ion (F^-), the recommended and permissible ion concentration levels provided by both WHO (2011) and SON (2007) are given as 1.0 *mg/l* and 1.5 *mg/l* respectively. The values of ions concentration obtained from this study are found to be within the recommended values when compared with the WHO (2011) and SON (2007) standards.

Table 2: Physicochemical composition of samples collected from Muna groundwater

Sample ID.	Ca^{2+} (*mg/l*)	Mg^{2+} (*mg/l*)	Fe^{2+} (*mg/l*)	Cl^- (*mg/l*)	SO_4^{2-} (*mg/l*)	NO_3^{2-} (*mg/l*)	F^- (*mg/l*)	K^+ (*mg/l*)
MNK 1	6.910	1.53	0.16	1.21	7.00	1.76	0.13	8.30
MNK 2	121.0	1.22	0.18	1.22	4.58	1.61	0.15	8.65
MNK 3	115.0	1.40	0.15	1.22	4.58	1.61	0.15	8.90
MNP 4	136.0	1.48	0.12	1.50	4.60	1.62	0.18	9.30
MNP 5	93.00	1.38	0.23	1.24	15.8	10.1	0.18	8.40
MNM 6	76.20	1.30	0.22	2.66	15.0	8.10	0.25	8.50
MNM 7	125.0	1.60	0.17	1.30	26.8	1.81	0.13	12.5
MNF 8	6.900	16.3	0.11	1.80	0.28	1.60	0.10	12.4
MNF 9	20.60	5.40	0.13	2.40	1.09	1.62	0.12	11.2
MNF 10	11.20	15.8	0.14	2.60	16.1	1.66	0.11	11.5
MNE 11	8.480	12.6	0.16	2.40	6.01	1.59	0.14	12.3
MNE 12	72.72	3.49	0.18	9.60	49.3	1.58	0.15	12.4
MNKR 13	25.89	11.4	0.10	2.20	7.28	8.00	0.16	13.1
MNKR 14	18.80	9.62	0.12	2.60	6.33	8.11	0.16	14.8
MNKR 15	18.98	1.47	0.13	2.40	1.38	1.80	0.17	14.5
MNG 16	33.15	3.62	0.20	8.80	49.8	1.70	0.10	10.8
MNGS 17	33.96	1.20	0.19	2.40	8.62	1.82	0.13	10.1
MNC 18	35.02	1.25	0.21	2.42	2.02	10.0	0.14	11.1
MNC 19	34.19	2.16	0.24	3.00	8.16	10.0	0.15	12.6
MNC 20	4.800	11.4	0.11	1.60	3.46	1.63	0.14	10.5
Minimum values	4.800	1.22	0.10	1.21	0.28	1.58	0.10	8.30
Maximum Values	136.0	16.3	0.24	8.80	49.8	10.1	0.18	14.8
Mean	49.89	5.28	0.16	2.73	11.9	3.88	0.15	11.1
Range	131.2	15.1	0.14	7.59	49.5	8.52	0.08	6.50

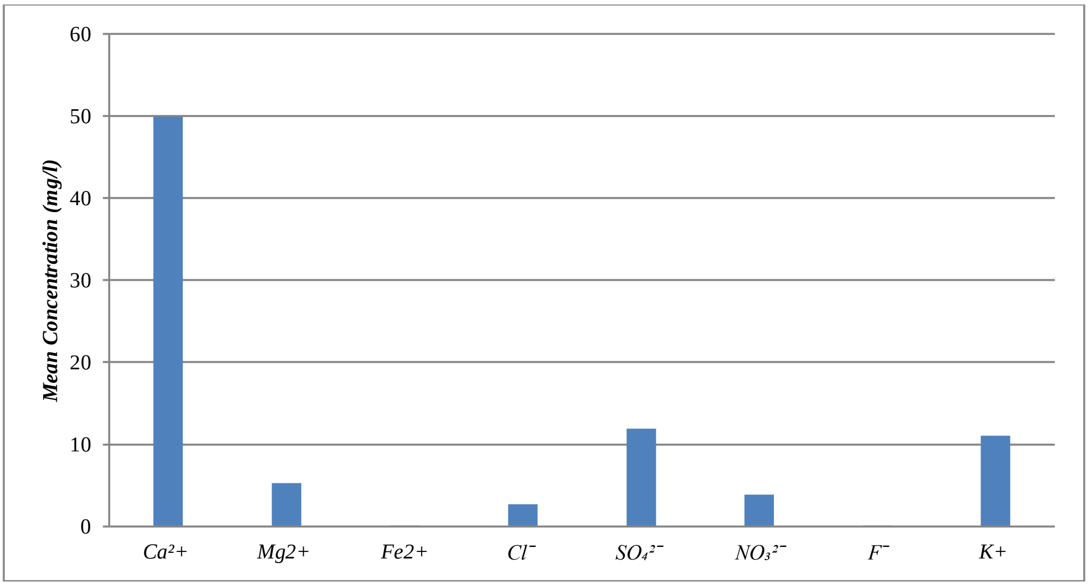

Figure 1: The mean concentration of some physicochemical composition of groundwater samples collected from the Muna area

Figure 1 shows the mean cations and anions concentration level of the groundwater sample collected from the Muna area. The cations are in the sequence of $Ca^{2+} > Mg^{2+} > K^{+} > Fe^{2+}$ and for anions the sequence are $SO_4^{2-} > NO_3^{2-} > Cl^{-} > F^{-}$. Indeed, there is a possible change during distribution and usefulness and importance in domestic, agricultural and industry with the need for and response to purification and concentrations that has to be in line with world health organization (WHO) and standard organization of Nigeria (SON). Therefore, for Water quality control, once groundwater quality cannot be controlled, restored, and managed, then it is difficult to clean it up to have sustainable water for both human consumption and other activities.

IV. CONCLUSIONS

The study was carried out to investigate the geophysical properties of the groundwater samples collected from the Muna area. The quality of the groundwater samples was then analyzed the using direct reading (DR) spectrophotometer kits test. The groundwater samples were analyzed for both physical and chemical parameters such as electric conductivity, turbidity, temperature, calcium, (Ca^{2+}), magnesium, (Mg^{2+}), potassium, ($K+$), iron, (Fe^{2+}), sulfates, (SO_4^{2-}), nitrate, (NO_3^{2-}) chloride (Cl^{-}) and fluoride ion (F). The result shows that the concentrations level sequence for cations and anions are in the order of $Ca^{2+} > Mg^{2+} > K^{+} > Fe^{2+}$ and $SO_4^{2-} > NO_3^{2-} > Cl^{-} > F^{-}$ respectively. All the values of ions concentration obtained from this study are found to be within the recommended values when compared with the WHO (2011) and SON (2007) standards. There is a need to have data on groundwater conditions, collections, and trends to encourage the communities on sustainable groundwater management. Groundwater quality strategy needs to be developed and implemented from different disciplines. Therefore, the current study can be enhanced with new tools based on a scientific approach.

REFERENCES

[1] M. Hassan, Y. H. Ngadda and A. Adamu, "Health Risk Assessment of some Heavy Metals in Drinking Water Due to Mining Activities in Gombe Area, Northeastern Nigeria." IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT), 14(7), (2020): pp 37-42.

[2] A. S. Mahmoud, E. Emmanuel, J. Joseph, et al., "Chemical evaluation of commercially bottled drinking water from Egypt." Journal of food composition and analysis,14, (2001): pp 127–152.

[3] I. S. El-Kowrany, E. A. El- Zamarany, K. A. El-Nouby, D. A. El-Mahy, E. A. Ali, A. A. Othman, W. Salah, A. A. El-Ebiary, "Water pollution in the Middle Nile Delta, Egypt: An environmental study." Journal of Advanced Research, **7**, (2016) pp 781–794.

[4] O. Anomohanran, "Groundwater potentials in Asaba, Nigeria using surface geoelectric sounding." International journal of physical science 6, (2011) pp 7651-7656.

[5] F. O. Ugbede, B. C. Aduo, O. N. Ogbonna, O. C. Ekoh, "Natural radionuclides, heavy metals, and health risk assessment in surface water of Nkalagu river dam with statistical analysis." Scientific African, 8 (2020) e00439.

[6] S. Singh, L. M. Mosley, Trace metals level in drinking water on Viti Levu, Fiji Islands. The south pacific journal of natural and Applied science,21(1), (2003), 31–34.

[7] D. Kantoma, J. Yusuf and M. Y. Bidam, Assessment of Heavy Metals Concentration in Drinking Water Samples from Selected Areas of Kauru Local Government Area of Kaduna State, Nigeria. Bayero Journal of Pure and Applied Sciences, 10(1), (2017), 509 – 515.

[8] C. W. Montgomery, "Environmental geology." Magraro-hill companies inc. NL, (2000), 546.

[9] M. Z. Bunu, Groundwater management perspective for Borno and Yobe states, Nigeria. Journal of environmental hydrology, 7(19), (1999), 1-10.

[10] K. L. Stun, J. I. Morgan, Aquifer chemistry: an introduction emphasizing chemical equilibrium in natural water, New York. Willey inters science, (1981), pp. 780.

[11] World health organization (2015): World health organization standards for drinking water quality (4thedition), a world health organization.

[12] Standard organization of Nigeria (2007): Nigeria standard for drinking water quality, 17.

[13] P. Kumar, Tracing the factors responsible for arsenic enrichment in groundwater of middle Gangetic plain India. A source identification perspective, 32(2), (2013) 129-146.

[14] N. H. Al - Saigh, Geo-electric detection of surface faults at the Western embankment of Badoosh reservoir, Northern Iraq. Journal of applied science environment sanitation, 5, (2010) 65-72.
[15] R. K. Trivedy and P. K. Goyal, Chemical and Biological methods for water pollution studies. Environmental publications, Karad, (1986).
[16] S. M. Adelana, P. L. Olsehinde, P. Vibka, Isotope and Geochemical characterization of surface and subsurface matters in the semi-arid Sokoto basin Nigeria. Africa Journal science technology (AJST), 4(2), 2003 50-89.