Medical Geology and Geostatistical Investigation of Surface Water and Groundwater Quality; Health Challenges in Auchi, Nigeria

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Abstract-Water is an integral part of human existence, its quality is of great significance to its uses, which can serves as a frame work for medical investigation for spread and trends of water borne diseases. This research is aimed at investigating the possible impact of surface water and groundwater quality on human's health. The study area lieswithin latitude $7^0 06^1$N and 7^0 11^1 and longitude 6^0 08^1 E and 6^0 15^1. The study was conducted by collection of surface water and groundwater samples for physico-chemical and microbial analysis. The study shows that the physico-chemical parameters of the water falls within the World Health Organization (WHO) and the Nigerian Standard of Drinking Water Quality (NSDWQ) permissible limits, with the exception pH indicating that the water is slightly acidic, iron (Fe), manganese (Mn), and Cadmium (Cd) and Lead (Pb) that are slightly above the permissible limits.The health risk assessment of the water is based on the acidic nature of the water and the heavy metals that are above the permissible limits of WHO and NSDWQ. The concentration of Fe and Mnhas a positive correlation with the pH indicating a geogenic origin of the heavy metals, while Cd and Pb has a negative correlation with the pH of the water and they are probably due to anthropogenic activities than geogenic origin. The microbial presence of the water is low, which is probably responsible for the low value of biological oxygen demand of the water. The possibly health challenges from prolong intake of the water includes possible neurological disorder and carcinogenic health risk. The acidic nature and the high Fe concentration of the water possibly have a secondary health impact on the human.

Indexed Terms- Water quality, health challenges, physico-chemical parameters, carcinogenic

I. INTRODUCTION

Water is important in the existence of human and it forms an integral section of the agricultural and industrial hub. The quality of the water is of great significant to its uses, it defined the potability and usage of the water. The quality of the water is usually affected by anthropogenic and geogenic activities. Groundwater serves as a major source of potable water supply compared to surface water which is readily prone to pollution. The quality of water can serves as a frame work for medical investigation for spread and trends of water borne diseases. This is important to the recent development in the field of medical geology, in areas of health and environmental sustainability. The groundwater contains dissolved substances and other parameters (such as pH and electrical conductive). The major dissolved components of groundwater and its constituents are typically present at concentrations in the range of a few mg/L to several hundred mg/L. Other minor chemical constituents occurring in low concentrations are boron [1].This research is aimed at investigating the possible impact of surface water and groundwater quality onhuman's health in the study area.Umoru*et al.* (2021), conducted a research on the groundwater quality in part of Igarra, Edo State, the study revealed a Ca>Mg>Na>K concentration sequence of cations and a HCO_3>Cl>NO_3>SO_4>NO_2concentration sequence of anions in the groundwater, with Ca-HCO_3 water type, the heavy metals has a concentration sequence of Fe>Mn>Cu>Zn>Cr>Pb>Cd>Ni>V. The study concluded that the geology and water-rock interaction

is responsible for high heavy metals concentration in the groundwater of the study area, which poses serious health risks to the inhabitants of the area.

II. THE STUDY AREA

The study area lies within latitude $7^{0}06^{1}$N and 7^{0} 11^{1} and longitude 6^{0} 08^{1} E and 6^{0} 15^{1}, in the south-south geo-political zone of Nigeria, and it can be accessed through the Auchi-Benin express road. Figure 1 shows the location of the study area.

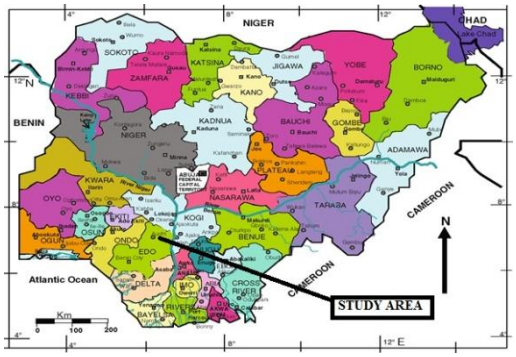

Fig. 1: Map of Nigeria showing the Study Area

The study area is characterized by two distinct seasons; the dry and rainy seasons. The dry seasons which occurs between November-April and it is associated with hamattan that comes up between late November and February which is characterized by dust knew winds as a result of the North East or trade wind. The rainy season spans from April-November, with an average of about 100cm-15cm, the south west trade wind brings the rain for wet season [1]. The vegetation of the area falls within the guinea savannah and it topography is undulating with a ruggy relief.Geologically, the study area lies within the Anambra Basin and the south-western basement complex of Nigeria. The Anambra Basin distinctively belongs exclusively to Nigeria [3]. It is a structural depression located at the south-western of the Benue Trough. The area is drained by River Orle and River Niger and poses a dentrital drainage system with the Ajali sandstone as the aquiferous formation in the area. Figure 2 show the geology of Nigeria.

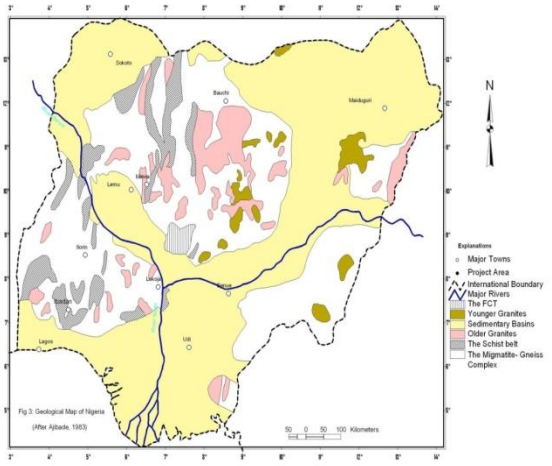

Fig. 2: Geology map of Nigeria [4].

The physico-chemical parameters of the groundwater reveal its geological origin, water-rock inkteraction, residence time in the aquifer and the hydrogeology of the water, which in-turn defines the suitability of the water for utility and consumption. The low water quality and the presence of coliform organism and other micro-organism harmful to human in the groundwater, are responsible for waterborne diseases and these diseases. Aremu*et al*. (2011) evaluated the physico-chemical properties of well, borehole and stream waters in Kubwa, Bwari Area Council, FCT, Nigeria. The groundwater samples in the area are moderately acidic to strongly alkaline, while the surface water is neutral to moderately alkaline in nature. They revealed that some parameters as pH, iron, TDS, potassium and chloride do not conform to the World Health Organization [6] and Nigeria Standard for Drinking Water Quality [7].

III. METHODOLOGY

The research was conducted by collecting 10 surface water and groundwatersamples from the study area into the sample containers, forinsitu water testing and laboratory analysis for the hydro-chemical and microbial analysis.pH meter was used for insitu testing to determine the pH, EC and TDS. Atomic Absorption Spectrophotometer (AAS), Spectronic 20D+ Spectrophotometer and titrametric apparatus was used for the laboratory analysis for the cations, anions and heavy metals determination.The microbial parameters monitored included total heterotrophic bacterial counts and total coliform counts, according

the methods of APHA [8]. The result of the analysis was compared withWorld Health Organization and Nigeria Standard for Drinking Water Quality to determine the health implications of the water. Geo-statisticalevaluation of the water quality was done. Table I shows the physico-chemical parameters that was analyzed in the water of the study area.

Table I: Analyzed physico-chemical parameters in the water of the study area

Parameter
pH
Electrical Conductivity (EC, µS/cm)
Salinity (Sal., mg/l)
Total Dissolved Solid (TDS, mg/l)
Dissolved Oxygen (DO, mg/l)
Biochemical Oxygen Demand (BOD, mg/l)
Chemical Oxygen Demand (COD, mg/l)
Bicarbonate (HCO_3, mg/l)
Chloride (Cl, mg/l)
Sulphate (SO_4, mg/l)
Nitrite (NO_2, mg/l)
Nitrate (NO_3, mg/l)
Phosphate (P, mg/l)
Sodium (Na, mg/l)
Potassium (K, mg/l)
Calcium (Ca, mg/l)
Magnesium (Mg, mg/l)
Iron (Fe, mg/l)
Manganese (Mn, mg/l)
Copper (Cu, mg/l)
Zinc (Zn, mg/l)
Lead (Pb, mg/l)
Cadmium (Cd, mg/l)
Chromium (Cr, mg/l)
Nickel (Ni, mg/l)
Vanadium (V, mg/l)

IV. RESULTS AND DISCUSSION

A. Geo-statistical analysis

The table II shows the geo-statistical summary of physico-chemical analysis of water and table III shows the microbial analysis of the water samples from the study area.

Table II: Geo-statistical Summary of Physico-chemical Analysis of Water from the Study Area

Parameters	Mean value	Std. dev.	Max. value	Min. value	WHO	NSDWQ
pH	5.74	0.77	4.40	6.70	6.5 - 8.5	6.5 - 8.5
EC	120.92	71.41	57.50	289.00	500	1000
Sal.	0.06	0.03	0.03	0.13	-	-
TDS	76.89	33.15	28.80	145.00	500	500
DO	3.36	1.69	1.40	6.10	-	-
BOD5	0.57	0.28	0.10	0.90	-	-
COD	12.24	8.61	3.20	30.50	-	-
HCO_3	50.45	47.29	12.20	140.30	-	-
Cl	45.41	18.19	20.90	77.30	250	250
SO_4	0.20	0.21	0.01	0.69	250	100
NO_2	0.03	0.03	0.00	0.09	0.2	0.2
NO_3	1.64	1.19	0.40	3.36	10	50
P	0.14	0.14	0.05	0.46	-	-
Na	0.53	0.32	0.19	1.12	200	200
K	0.13	0.07	0.03	0.28	-	-
Ca	1.78	0.60	0.64	2.28	-	-
Mg	1.09	0.54	0.28	1.87	20	0.2
Fe	0.36	0.04	0.32	0.45	0.3	0.3
Mn	0.49	0.31	0.08	0.99	0.1	0.2
Cu	0.39	0.27	0.05	0.84	0.5	1.0
Zn	0.88	0.53	0.14	1.54	5.0	3.0
Pb	0.04	0.04	0.01	0.12	0.01	0.01
Cd	0.008	0.003	0.001	0.008	0.003	0.003
Cr	0.03	0.01	0.00	0.02	0.05	0.05
Ni	0.02	0.02	0.00	0.05	0.02	0.02
V	0.01	0.01	0.00	0.04	-	-

Std dev. – standard deviation, max. – maximum, min. – minimum.

Table III: Microbial Analysis of the Water Samples from the Study Area

S/n	Total Heterotrophic Bacterial Counts (cfu/ml) x 10^3	Total Coliform Counts (cfu/ml) x 10^3
1	1	0
2	1	0
3	1	0
4	1	0
5	1	0
6	1	0
7	1	0
8	3	0
9	4	0
10	2	0

The permissible limits for total Coliform count is 10 cfu/ml.

The physico-chemical analysis of the water in the study area shows that the pH of the water has an average value of 5.74±0.77. This indicates that the water in the area is slightly acidic. The EC of the water have an average concentration of 120.92±71.41

mg/l, a low salinity of an average concentration of 0.06±0.03 mg/l and TDS of an average concentration of 79.89±33.15 mg/l. The DO of the water has an average concentration of 3.36±1.69 mg/l, BOD of an average concentration of 0.57±0.28 mg/l and a COD of an average concentration of 12.24±8.61 mg/l. The anion concentration, HCO_3 has an average concentration of 50.45±47.29 mg/l, Cl of an average concentration of 45.41±18.19 mg/l, SO_4 of an average concentration of 0.20±0.21 mg/l, NO_2 of an average concentration of 0.03±0.03 mg/l, NO_3 of an average concentration of 1.64±1.19 mg/l and P of an average concentration of 0.14±0.14 mg/l. The cations concentration Na has an average concentration of 0.53±0.32 mg/l, K of an average concentration of 0.13±0.07 mg/l, Ca of an average concentration of 1.78±0.60 mg/l and Mg of an average concentration of 1.09±0.54 mg/l. The heavy metals present in the water has an average Fe concentration of 0.36±0.04 mg/l, Mn of an average concentration of 0.49±0.31 mg/l, Cu of an average concentration of 0.39±0.27 mg/l, Zn of an average concentration of 0.88±0.53 mg/l, Pb of an average concentration of 0.04±0.04 mg/l, Cd of an average concentration of 0.008±0.003 mg/l, Cr of an average concentration of 0.03±0.01 mg/l, Ni of an average concentration of 0.02±0.02 mg/l and an average V concentration of 0.01±0.01 mg/l. Figure 3 shows the various water constituents and figure 4 shows the heavy metals concentration in the water of study area.

The microbial analysis of the water shows that the Coliform bacterial in the water is low and falls below the WHO and NSDWQ permissible limits.

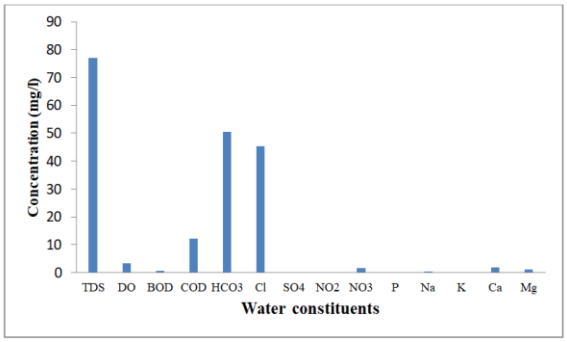

Fig. 3: Water constituents in the study area

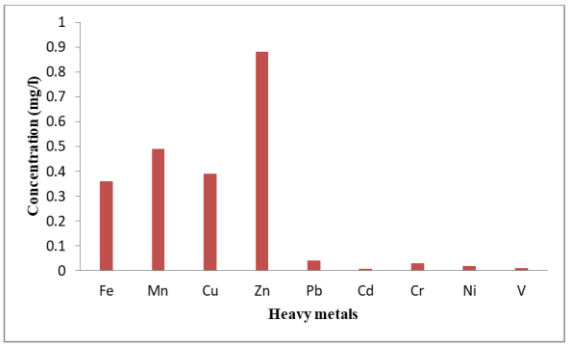

Fig. 4: Heavy metals concentration in the water of study area

Piper diagram which is a hydrochemistry diagram used for the classification of the water type or facies, was used to classified the water type. The piper diagram (figure 5) shows that about 90 % the water in the area is of Calcium-Chloride (Ca-Cl), and about 10% of Calcium-bicarbonate (Ca-HCO_3) water type.

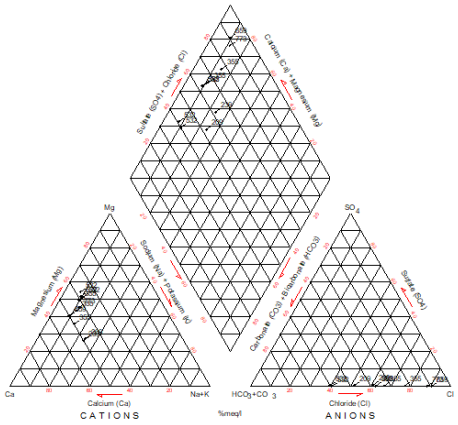

Fig. 5: Piper diagram for water type in the study area

B. Health Risk Assement

The health risk assessment of the water is based on the acidic nature of the water and the heavy metals that are above the permissible limits of WHO and NSDWQ. The water is found to have pH, Fe and Mn which exceeded the permissible limits with Cd and Pb slightly higher than the permissible limits. Figure 6 shows the correlation of pH, EC, TDS, DO, BOD, COD and heavy metals of the water in the study area

Parameters	pH	EC	TDS	DO	BOD	COD	Fe	Mn	Cu	Zn	Pb	Cd	Cr	Ni	V
pH	1														
EC	0.59	1													
TDS	0.74	0.81	1												
DO	0.49	-0.18	-0.03	1											
BOD5	-0.45	0.34	0.10	-0.75	1										
COD	-0.20	0.09	0.28	-0.75	0.49	1									
Fe	0.27	0.59	0.52	0.15	0.09	-0.26	1								
Mn	0.02	-0.06	-0.30	0.47	-0.43	-0.69	0.45	1							
Cu	-0.02	-0.14	-0.39	0.44	-0.44	-0.66	0.31	0.99	1						
Zn	-0.01	-0.09	-0.32	0.48	-0.43	-0.75	0.47	0.99	0.97	1					
Pb	-0.09	-0.17	-0.45	0.12	-0.30	-0.34	-0.05	0.78	0.86	0.71	1				
Cd	-0.08	-0.14	-0.39	0.16	-0.27	-0.31	0.00	0.79	0.86	0.71	0.98	1			
Cr	0.00	-0.06	-0.26	0.47	-0.41	-0.75	0.55	0.96	0.92	0.99	0.62	0.60	1		
Ni	-0.05	-0.15	-0.42	0.23	-0.33	-0.42	-0.01	0.82	0.90	0.76	0.98	0.99	0.66	1	
V	-0.05	-0.12	-0.39	0.20	-0.29	-0.36	0.03	0.81	0.88	0.73	0.98	1.00	0.63	0.99	1

Fig. 6: Correlation of pH, EC, TDS, DO, BOD, COD and heavy metals of the water in the study area

The correlation as shown in figure 6 indicates that pH has a positive correlation with TDS, EC, DO, Fe and Mn, with a negative correlation with BOD, COD, Cu, Zn, Pb, Cd, Ni and V. This revealed that as the water in the study area becomes more acidic, the concentration of Fe and Mn in the water probably increases. The concentration of Fe and Mn has a significant rock – water relationship indicating ageogenic origin of the heavy metals. The negative correlation of Cd and Pb in the water indicates that as the pH of the water increases, their concentration decreases, the pH of water influences the chemical dissolution of rocks and this is shows that their concentration in the water is probably due to anthropogenic activities than geogenic origin, as there is no significant rock – water relationship in their concentration, there accumulation is probably from leachate into the water body.The low values of biological oxygen demand (BOD) is an indication that the microbial presence of the water is low. The major possibly health challenges from intake of the water includes possible neurological disorder from excessive intake of Mn. Also, continuous exposure and intake of the water with Cd and Pb slightly above the recommended permissible limits over a period time can probably poses carcinogenic risk to human [7].The acidic nature of the water and the high Fe concentration of the water possibly have a secondary health impact on the human especially the infants and the aged persons in the community.

CONCLUSION

The quality of the water is usually defined the usage of the water and it is been affected by anthropogenic and geogenic activities. The quality of water can serves as a frame work for medical investigation for spread and trends of water borne diseases. This research evaluates the health impact of the water quality. The study shows that the health risk assessment of the water is based on the acidic nature of the water and the heavy metals that are above the permissible limits of WHO and NSDWQ. The water is found to have pH, Fe and Mn which exceeded the permissible limits with Cd and Pb slightly higher than the permissible limits. The concentration of Fe and Mn is has a positive correlation with the pH indicating a geogenic origin of the heavy metals and the Cd and Pb in the water has a negative correlation with the pH of the water and they are probably due to anthropogenic activities than geogenic origin. The low value of biological oxygen demand is an indication that the microbial presence of the water is low. The major possibly health challenges from intake of the water includes possible neurological disorder from excessive intake of Mn. Also, continuous exposure and intake of the water with Cd and Pb slightly above the recommended permissible limits over a period time can probably poses carcinogenic risk to human. The acidic nature of the water and the high Fe concentration of the water possibly have a secondary health impact on the human especially the infants and the aged persons in the community.

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