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Physico- Chemical Characteristics of Water Quality in Kano River Drainage Basin, North - Western Nigeria

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Abstract
The study involves physico chemical investigation of the water quality of Kano Rivers and its adjoining groundwater from its headstream up to its downstream in order to ascertain it suitability for human consumption, domestic and agricultural usage. Results show that the water is slightly alkaline, EC ranges from 7-159 Us/cm and average of 29.5 US/cm, pH ranges from6.6-8.7 and average of 7.18, and TDS ranges from 7-128 and mean average of 24.79, Ca ranges from 3.22-128.81ppm and an average of 25.56ppm, Mg ranges from 0.06-175.17 ppm and average of 10.62, (exceeds limits), Na ranges from 3.65-970..48 and an average of 54.17, K ranges from 2.72-52.52 ppm and average of 9.98ppm for the anions contents results shows that HCO_3 ranges from 2746-4863.3 and average of 277.9 ppm, SO_4 ranges from 2.15-147.1ppm and an average of 11.27ppm,Cl ranges from 0.08-116.19ppm with average of 15.25ppm, NO3 ranges from 0.94-47.49ppm with average of8.09ppm then PO_4 ranges from1.26-1.26ppm with average of 1.26ppm. All the analysed parameters shows that the water is heavily polluted in comparison with NIS (2007), EPA (2004) and WHO (2011) guidelines and ones determined by Schoeneich (2010) for the Crystalline Shield of northern Nigeria. pH is slightly higher of average 7.18 and can be related to TDS contents. Three chemical water types were determined based on their locations, upstream Kano is $CaHCO_3$ type, for the midstream is $NaHCO_3$ as well as downstream is also $NaHCO_3$ types with only one showing $MgHCO_3$ in Surface water of Hadiyau village.
Keywords: Major ions, pollution, Water types, Crystalline Shield

1.1 Introduction:

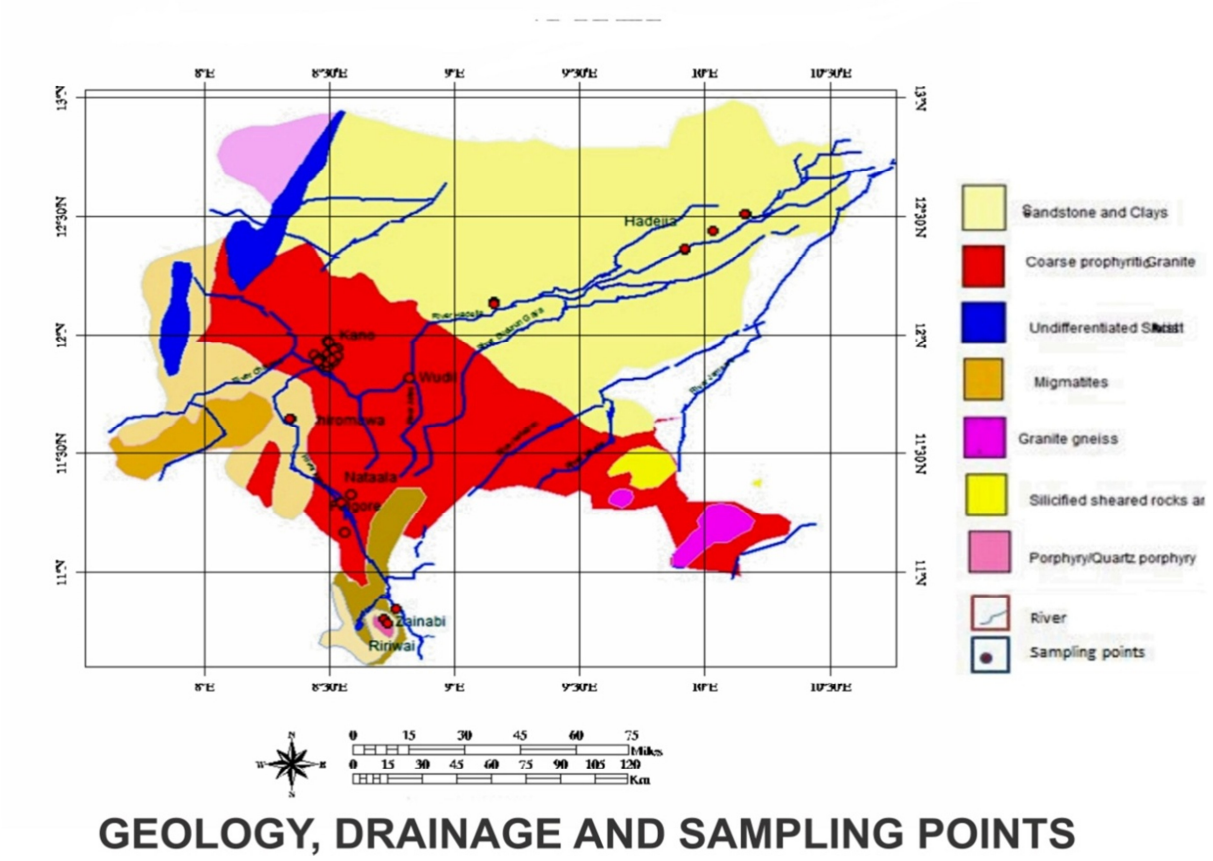
Kano State, one of the most populous urban centers in Nigeria, with a population of over 5 million people, is also one of the most industrialized towns in Nigeria. As such, it pollutes surface and groundwater in Kano River drainage basin. This paper aims at determining levels of major ions from both industrial and residential pollution of water in Kano River drainage basin, upstream and downstream from the pollution city. (Figure1).

Kano River downstream of Kano also called Hadejia River, drains residential and industrial effluents of Kano metropolis and then flows to the Hadejia-Nguru wetlands as an inland which is a major food basket for Nigeria. This river upstream and downstream from Kano with boundary between the central Nigeria crystalline Shield and Chad formation is effluent, while within the Borno Basin it becomes influent down to the Hadejia Nguru Inland Delta, where it disappears in the sands of Chad Formation.

This study is aimed at investigating levels of major ions in water pollution both surface and groundwater along Kano River from its headstream up to downstream down to Hadejia-Nguru wetlands, to answer this question, whether pollution caused by Kano metropolis reaches Hadejia Nguru wetlands one of the food basket of Nigeria where it can affect quality of food produced under irrigated farming.

1.2 Location, Extent and Accessibility

The study area covers the present Kano and Jigawa states and lies within latitudes 10^0 45”- 12^0 30”N and longitudes 8^0 43”-10^0 10”. The river has a total length of 1,384 km, and its drainage basin is....? Km. It is part of Lake Chad Drainage Basin. The River flows through normal non polluted areas of Nigeria, with exception to Kano metropolis, where from it drains most of its pollutants. Kano River flows from the foot of the Jos Plateau on the Pre-Cambrian rocks of the central Nigerian Crystalline Shield under the effluent regime. Passing through Kano Metropolis it drains its residential and industrial effluents, then, some 40 KM downstream Kano metropolis, enters the Borno basin, Changes its regime into influent one, and finally disappears in the sands and silts of the Chad formation in the Hadejia-Nguruwetlands.



GEOLOGY, DRAINAGE AND SAMPLING POINTS

2. Materials and methods

Water sampling was carried out in February/ March during the dry season and a total of 34 samples were taken from the river as well as from both hand dug wells and boreholes tapping the soft overburden and fractured crystalline aquifers. Samples were randomly taken but evenly distributed from upstream to its downstream. Samples from river water were collected from midpoint and bottom below surface water and were filtered using a cellulose filter of 0.45microns diameter. In situ measurement was also made of some parameters was made of conductivity, temperature, pH, time, TDS as well as coordinates inclusive, elevations and depth of water level. Then the polythene bottles of 120 mg/l were rinsed two times before being capped and tightened and were kept upright in container. Also before tightening samples were acidified with concentrated HNO_3 to pH of 1-2, stored and freeze.

Samples then were taken to the Institute of Environmental Engineering laboratory of the Polish Academy of Science in Zabrze Poland.

In analysing samples to determine levels of concentrations of major ions ion chromatography was used using a Metro ohm ion chromatography (Hensau- metro ohm AG, Switzerland). Calibration of the sample analysed was done. Results were displayed in computer in form of chromatograms from the flow rate that shows levels of concentrations and results was extracted and tabulated.

3.1 Results and Discussions

Data obtained from field measurement are for conductivity, total dissolved solids, elevation above sea level, temperature of water, pH and Conductivity ranges from 7 – 159 Us/cm with average of 29.5Us/cm pH ranges from 6.52 - 8.7 and an average of 7.18, Water temperature ranges from 69.2 – 194 ^{0}F and an average of 88^{0}F with elevations range between 343 – 880 mm with an average of 472.69m. TDS ranges from 7 - 128 and average of 67.5

Na ranges from 3.65 – 970 ppm and average of 105.156 ppm, K ranges from 2.72 - 43.57ppm and average of 19.385 ppm, Ca ranges from 3.22 - 66.79 ppm with average of 49.655ppm, Mg ranges from 0.06 - 32.07ppm with an average of 10.616 ppm, all in milligrams per litre or parts per million. Also for the anions in the water of the area HCO_3 ranges from 27.46 - 486.24 ppm with average of 277.902 ppm, NO_3 range between from 0.94 - 226.65 ppm with an average of 15.631 ppm, F ranges from 0.06 - 8.58 ppm with an average of 4.326 ppm and Br and PO_4 of range between 1.2-69.22 ppm with average of 4.326- 1.26 ppm and average of 1.26 ppm.

In comparison with levels obtained in the crystalline shield of north central Nigeria (Schoeneich, 2010)

are as follows: pH according to Schoeneich is 7.18 and for the studied area average is 7.2, this then means the water of the studied area is weakly acidic. Na in the studied area is 105.16 ppm higher than that of Schoeneich for both surface and groundwater of 1.7 ppm and 5.0 ppm respectively. K from this work is 19.39 ppm and for the one determined for the crystalline shield is 1.5 ppm and 3.0 ppm for both surface and groundwater, 6 times higher than for the shield determined by Schoeneich. Ca is 49.66 ppm but for the crystalline shield is 3.0 ppm again 14 times higher than that of the Crystalline shield. Also for Mg, from this work is 10.62 ppm much higher 10 times than that determined for the shield. HCO_3 is also higher with 277, 902 ppm than that of 34 ppm. NO_3 was 15.631ppm for the studied area and for the crystalline shield is 3.1 ppm and 1.35ppm for both surface and groundwater, in fact, 5 times and 14 times higher. For F is 4.33 ppm four times higher than that if 0.03 ppm far higher than that of Schoeneich. The only exceptional is TDS of Schoeneich is 60 ppm and the one determined for the studied area was 24.79 three times lower.

3.2 Water Types of the Studied Area

Water type in the study area determined form that samples taken which are 35 and majority from the Crystalline Basement shield and Chad formation water types is $NaHCO_3$ types with 17 samples indicating that based on AQQA software and also 16 samples are $CaHCO_3$ and only one (1) indicating $MgHCO_3$ type and is regarded as the best type. Also based on Sodium hazards according to Richard (1954) is as follows:

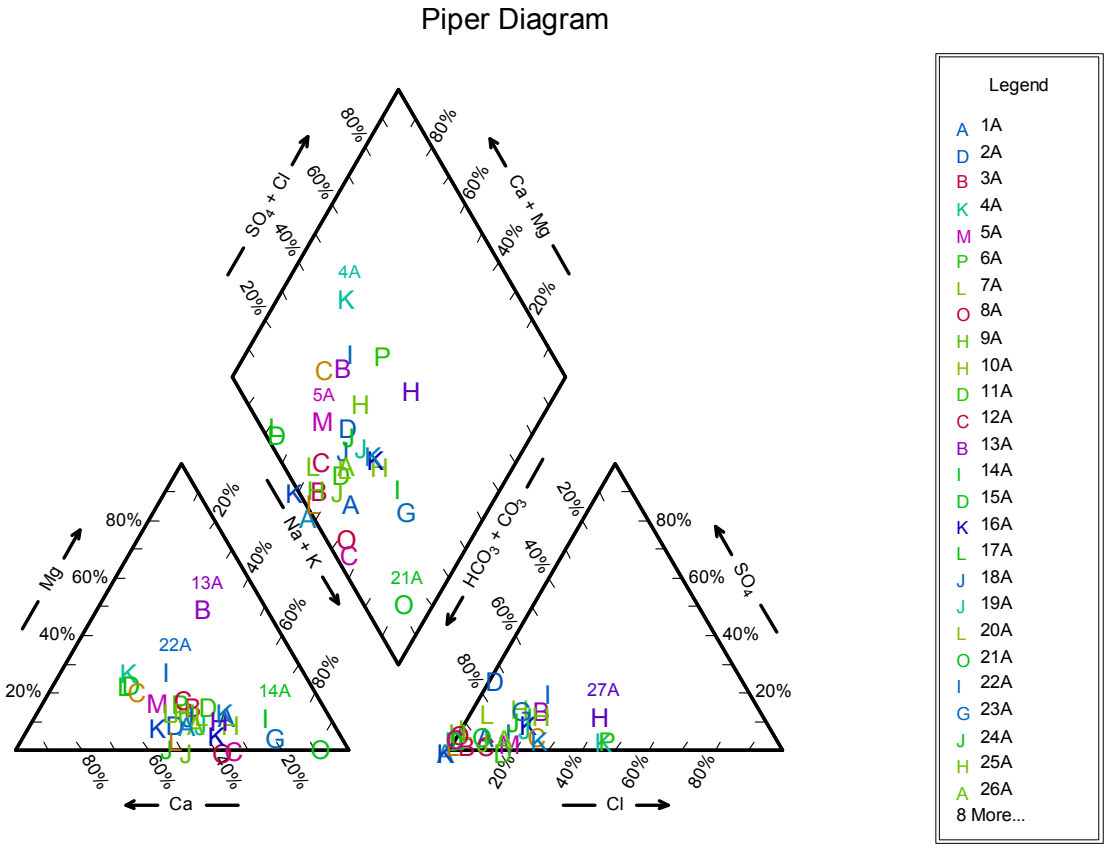


Fig. 2. A Plot of ions in the studied area both ground water and surface water samples

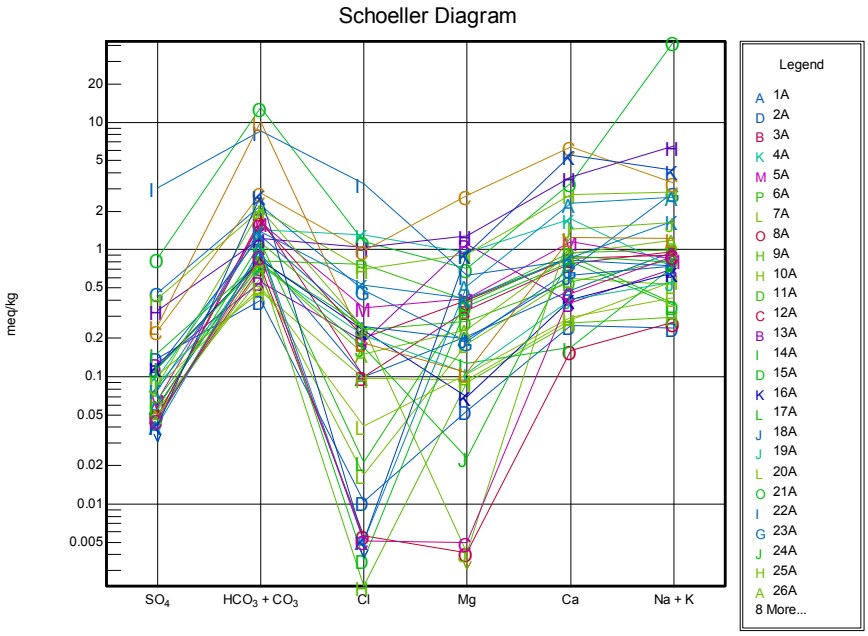


Fig.3. A plot of ions in the studied area both groundwater and surface from samples on Durov Diagram

It is worth while noting that for the Crystalline Shield hardness of $CaHCO_3$ is 20 ppm but for the studied area is, where as for $MgHCO_3$ is 24 ppm and for the study area is less of only 10.62 ppm. Predominant water type upstream Kano Metropolis is $CaHCO_3$ type, whereas, for the Central part of the river i.e. Kano metropolis also part of the Crystalline Shield like upstream is $NaHCO_3$ type. Also for the downstream is $NaHCO_3$ type with only that sample that indicates $MgHCO_3$ type in Hadiyau near Auyo town part of Chad Formation (surface water).

4. Conclusion

The study helps to investigate water from the study area on it physic- chemical character in both surface and groundwater and results shows that water of the area is slightly alkaline, the water is heavily polluted. From levels established indicated that the pollution rate which is mainly from the midstream has travelled down up to the downstream where the water is utilised for both domestic and irrigation system of agriculture. Three major water types were determined for the area: $NaHCO_3$, $CaHCO_3$ and $MgHCO_3$ 17, 16 and 11 samples respectively. However, levels of concentrations in the sampled and analysed water was compared with some standards and guidelines for both domestic and irrigation water standards; NIS (2007), WHO (2011) and EPA (2004). In comparison of levels obtained from the analysis with these listed standards and guidelines results shows that water in the study area is not fit for domestic use but within the permissible limit for irrigation based on Richards (1954) on SAR and USSL classification by Richard water is are S1 type i.e Excellent (21 samples) and unsuitable (11 samples), whereas on Salinity hazard water ranges from good to excellent with majority in excellence status. pH is slightly higher of average **7.18** and can be related to TDS contents probably (weakly alkaline).Another comparison with that obtained on the crystalline shield determined by Schoeneich (2010) also shows that is much higher in all results obtained.

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Table1. Results of Field Measurements on Locations, Time, pH, TDS, Elevations and Depth to Water table from Wells and Boreholes where possible

Sample Number, Name of Location and Type	Locations	Time	Temp.(^{0} F)	pH	TDS	Elev.(m)	Depth
01. Ririwai BH	10^0 45' 01.3'' 08^0 43 49.2	11:10 am	79.7	6.52	010	880	12.53
02. Ririwai (SW)	10^0 43' 59.0'' 08^0 44' 41.1''	12:49pm	84.6	7.28	007	875	
03. Zainabi (SW)	10^0 47' 43.2'' 08^0 46'504''	3:00pm	84.5	7.28	020	616	
04. Falgore (BH)	11^0 07'36.7'' 08^0 34'33.8''	8:52am	82.8	6.68	025	589.7	7 casing
05. Nataala (SW)	11^0 17'47.4'' 08^0 35'58.8	9.45	75.15	7.02	020	517.6	
06. Nataala (BH)	11^0 15'45.4'' 08^0 33'54.2''	10:42am	83.0	6.63	019	554.5	
07. Ciromawar Kwari (BH)	11^0 37 27.8''' 08^0 21'58.7''	1:00pm	83.9	6.54	011	468.1	
08. Chiromawa Kwari (SW)	11^0 37'27.7'' 08^0 21'39.4''	1:25	74.3	7.38	007	459.8	
09. Baure (SW)	11^0 50'51.0'' 08^0 29' 39.2''	'2:20pm	82.0	7.42	008	428.4	
010. Baure (BH)	11^0 50'46.1'' 08^0 29 '39.6''	2:35	81.7	6.79	008	434.2	
011. Majiawa (BH)	12^0 08' 02.8'' 09^0 09'51.2''	8:32	78.9	6.93	012	380.3	
012. Hadiyau (BH)	12^0 21'40.4'' 09^0 55'16.8''	9;52am	85.2	6.78	017	357.8	
013. Hadiyau (SW)	12^0 21' 55.0'' 09^0 55' 12/1''	10:05	75.2	7.44	010	346.9	
014. Tarabu (SW)	12^0 30' 40.4'' 10^0 09'45.8'	11:20	86.5	7.67	013	343.2	
015. Tarabu (BH)	12^0 30' 42.2'' 10^0 09'41.6''	11:32	84.8	6.78	012		
016. Gadar Ringim (SW)	12^0 07' 35.4'' 08^0 10'07.5''	8:10	69.2	7.77	008	380.3	
017. Hadejia (BH	12^0 26'30.9'' 10^0 01' 59.2''	12:25pm	86.0	6.78	013		
018. Wudil (SW)	11^0 47 '56.6'' 08^0 49'59.3''	7:59	71.3	8.70	010	403	
019. Wudil (BH)	11^0 47' 56.8'' 08^0 49' 58.9''	7:15	80.3	8.50	012		
020. Mahada (SW)	11^0 50'51.4'' 08^0 30' 34.7''	9:00am	70.8	7.44	072	427.4	
020. Mahada (SW)	11^0 50'51.4'' 08^0 30' 34.7''	9:00am	70.8	7.44	072	427.4	
021. Mahada (SW)	11^0 50' 43.2'' 08^0 30' 33.8''	9;35am	72.4	8.15	008	427.2	
022. Magama (SW)	11^0 52'22.6'' 08^0 30'35.9''	9:43	69.2	7.51	128		
023. Kaba (BH)	11^0 52'08.1'' 08^0 30'07.4''	11:00	83.0	7.32	021	432.7	
024. Rigafada (BH)	11^0 54'10.5'' 08^0 30' 34.1''	12:20	86.1	7.23	016	457.5	
025. Wailari Mosque (HW)	11^0 55' 06.5'' 08^0 32'21.5''	12:45	82.9	6.73	036	448.7	
026. Sabuwar Gandu (BH)	11^0 57'07.3'' 08^0 30' 40.4''	1:25pm	86.4 86.4	6.93	014	472.1	
027. Sharada phase 1(HW)	11^0 57'47.8'' 08^0 30'31.5''	2;52	82.0	6.92	066	466.7	
028. Maikalwa Pri.Sch (BH	11^0 55' 42.5'' 08^0 32'42.5	7:48am	79.5	7.27	070	453.0	
029. Wailari (SW)	11^0 55'25.1'' 08^0 32' 06.5''	8.15	194	7.05	159	442.8	
030. Sabuwar Abuja (BH)	11^0 53' 59.4'' 08^0 27' 24.2''	10:15	156	6.93	042	461.0	
031.Yandanko (SW)	11^0 52' 45.9'' 08^0 28'20.8''	11:00am	71.2	7.20	010	434.8	
032 .Waratallawa (BH)	11^0 53'50.2'' 08^0 32' 54.3''	4:20pm	154	7.08	026		
033. Tanburawa Mosque (BH)	11^0 52' 14.4'' 08^0 31'54.3''	4:45pm	87.0	6.78	060	462.7	
034. Jan Farms (BH)	11^0 52' 54.4'' 08^0 31'21.8''	5:05pm	194	7.45	067	440.2	
035. Rimin Zango BH)	11^0 52'15.3'' 08^0 28'05.3''	10:35am	83.6	6.56	016	449.8	
036. Sabuwar Gandu (SW)	11^0 57'27.6 08^0 30'48.2''	1:25pm	86.4	6.93	014	472.1	

Table 2. Summary and Comparison of Parameters in the Studied Water Samples on Major ions with WHO (2011), EPA (2004) and NIS (2007) Guidelines

Parameter	Unit	EPA (2004)	NIS(2007)	WHO (2011)	The Studied Area work(Range)	Mean from the worked area	Remark
Temperature	^{o}C	-	-		69.2-194^{0}F		Not regulated
Conductivity	US/cm	-	1000	1400	7-159	29.5	
Total Hardness	mg/L	-	150	500			
*TDS	mg/L	500	500	1000	7-128	24.79	Within limit
*pH	pH	6.5-8.5	6.5-8.5	6.5-8.5	6.6-8.7	7.18	Slightly higher
Ca	mg/L			75	3.22-128.81	25.56	Within limit
Mg	mg/L		0.2	50	0.06-175.17	10.62	Higher than limit
*Na	mg/L	-	200	50	3.65-970.48	54.17	Within limit
*K	mg/L	-	-	55	2.72-52.52	9.98	Within limit
HCO_3^-	mg/L	-	-	1000	2746-4863.3	277.9	Within limit
*SO_4^{2-}	mg/L	250	100	250	2.15-147.1	11.27	Within limit
*Cl	mg/L	250	250	250	0.08-116.19	15.25	Within limit
NO_3	mg/L	10	50	50	0.94-47.49	8.09	Within limit
PO_4	mg/L				1.26-1.26	1.26	

*Naturally occurring chemicals whose guidelines were not established by WHO so their values are proposed or secondary guidelines

Table3. Summary and comparison of studied parameters from the Area with One determined For the Crystalline Shield of Northern Nigeria (after Schoeneich, 2010)

Parameter	Study Area	Average from Nigerian Crystalline Shield	Remarks
pH	7.18	7.2	Weakly Alkaline
Conductivity/US/cm	29.5	250	Less
TDS	24.79	60	Less
Na^+ (ppm)	105.156	1.7 (Surface water) 5.0 (Groundwater)	Hundreds Times Higher
K^+ (ppm	19.385	1.5 (Surface water) 3.0 (Groundwater)	16 Times Higher
Ca^+ (ppm)	49.655	3.0	15 Times Higher
Mg^+ (ppm)	10.62	1.1	10 Times Higher
HCO_3 (ppm)	277.902	34	8 Times Higher
NO_3 (ppm)	15.631	3.1(Surface) 1.35(Groundwater)	% Times higher
F (ppm)	4.33	0.30	Four Times Higher

Table4. Sodium hazard from the Study area Based on USSL Classification (Richards, 1954)

Sodium Hazard	SAR equivalent per mole	Number from the Study area	Remark on quality
S1	10	21	Excellent
S2	10-18		Good
S3	18-26		Doubtful
S4 & S5	>26	11	Unsuitable

Table5. Also based on Salinity hazards indicates that the hazard is low (Richard, 1954)

Salinity hazard	EC (microhm/cm)	Result from the study area	Remark on quality
C1	100-250	25	Excellent
C2	250-750	8	Good
C3	750-2250	2	Doubtful
C3&C4	>2250	-	Unsuitable

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