

Assessment of Groundwater Quality in Parts of Ijoko Area, Sango-Otta Axis of Southwestern Nigeria

Victoria Abiola Dairo*

Department of Physical and Earth Sciences, Crawford University, Faith-City, Igbesa, Nigeria

Victor Oludare Fagoyinbo

Department of Physical and Earth Sciences, Crawford University, Faith-City, Igbesa, Nigeria

Godson Mac-tyger

Department of Physical and Earth Sciences, Crawford University, Faith-City, Igbesa, Nigeria

Abstract

A total of 26 water samples comprising of well, river and borehole waters were subjected to physico-chemical tests to evaluate its quality. The result of the physical characteristics shows that the average pH value, total dissolved solid and electrical conductivity is 4.9, 1027.31mg/L and 1526.92mg/L respectively. Thus, relatively above the desirable limit for drinking water while the ionic dominance of the major cations and anions reveal high concentration of Na⁺ and Cl⁻ amidst other ions in the order of Na⁺>Ca²⁺>Mg²⁺> K⁺ and Cl⁻>HCO₃⁻ > SO₄²⁻ respectively wherein the water was classified as belonging to Na-Cl facies and unsuitable for irrigation purpose.

Keywords: Anions; Cations; Salinity; Groundwater; Hydro-chemical facies.



CC BY: [Creative Commons Attribution License 4.0](https://creativecommons.org/licenses/by/4.0/)

1. Introduction

The term “Ground Water” was explained by Todd [1] as the water that occurs beneath the ground surface.

The fact that a well yield lots of water does not mean that the water is good enough for drinking; this is because water is an excellent solvent capable of dissolving materials it comes in contact with thereby making dissolved chemicals to be incorporated into groundwater.

Even though the ground is an excellent mechanism for filtering out particulate matters, dissolved chemicals and gases can still occur in large enough concentration in groundwater to be harmful to human health.

Groundwater could be contaminated from industrial, man-made products such as gasoline, oil, road salt, domestic and agricultural chemicals such as herbicides and pesticides. These cause the groundwater to become unsafe and unfit for human use.

Salt contamination of aquifer results from excess sodium and chloride transported into the ground water bringing about salinization which is the process of increasing the salt content in the water or soil.

In order to ascertain the quality of the groundwater widely consumed by the residents of Ijoko, Southwestern Nigeria and the transiting citizenry, groundwater from hand dug wells, rivers and boreholes were sampled to investigate and determine the quality of the ground water by carrying out physical and chemical analysis on collected water samples and comparing it with the drinking water standard by World Health Organization (WHO) and delineated the areas with high concentration of salt in the groundwater in the studied area.

2. Geologic Setting of the Studied Area

The study area forms part of the Eastern Dahomey basin, which is a very extensive sedimentary basin on the continental margin of the Gulf of Guinea, which extends from the Volta River delta Southeastern Ghana in the west, to the western flank of the Niger delta [2-5]. The Eastern Dahomey basin is bounded by the west in faults and tectonic structure associated with the landward extension of the Roman and Chain fracture zones. Its eastern limit marked by the Benin-hinge line is the Okitipupa ridge [6]. The tertiary sediments of the Dahomey basin thin out and are partially cut off from the sediments of the Niger delta basin against the ridge of basement rocks.

The stratigraphic setting of the eastern Dahomey Basin in the Southwestern Nigeria was described as having five (5) lithostratigraphic formations from Cretaceous to tertiary ages [4, 7, 8]. The successions from oldest to youngest include Abeokuta Group (Cretaceous), Ewekoro Formation (Paleocene), Akinbo Formation (Late Paleocene – Early Eocene), Oshosun Formation (Eocene) and Ilaro Formation (Eocene).

The sedimentary formation of the studied area includes; Quaternary sediments which comprises of loose alluvium deposits made up of coastal plain sands and Sand and Clay which makes up the Ilaro Formation.

The studied area, Ijoko (Ogba-Iyo Community) is about 8km from Sango-Otta, Southwestern Nigeria and located within latitude 6°44' and 6°46'N and longitude 3°15' and 3°17'E as shown in Figure 1 and 2.

Figure-1. Map Extract showing the topography and drainage pattern of Ijoko and its environs

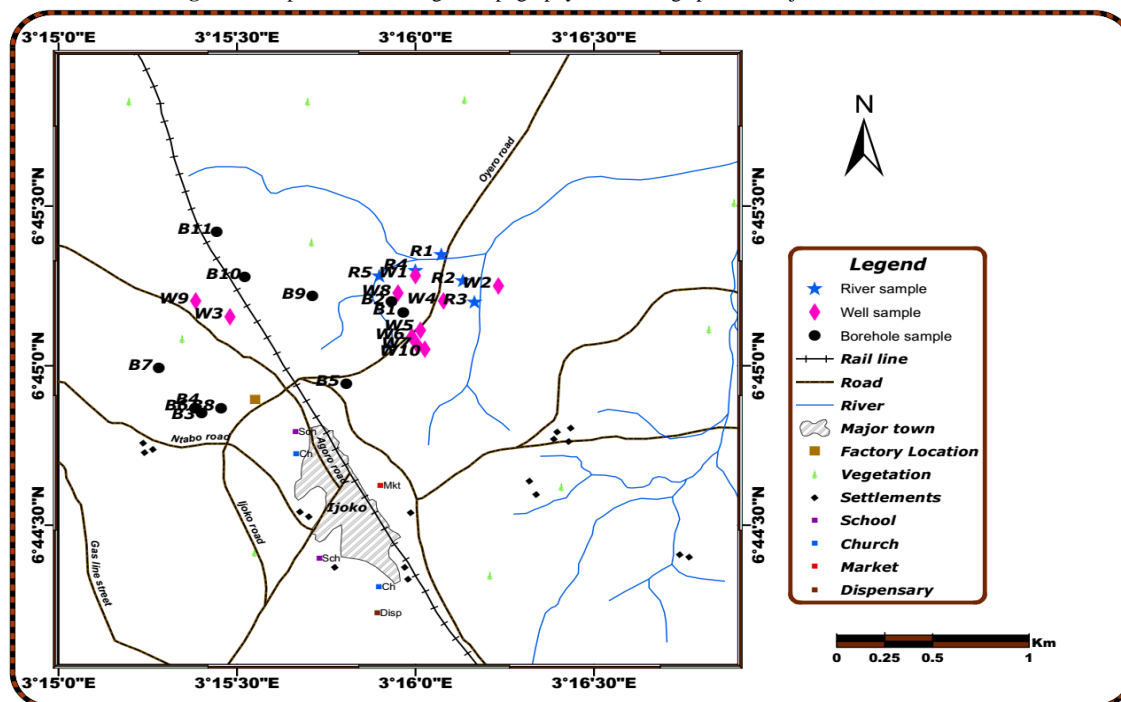
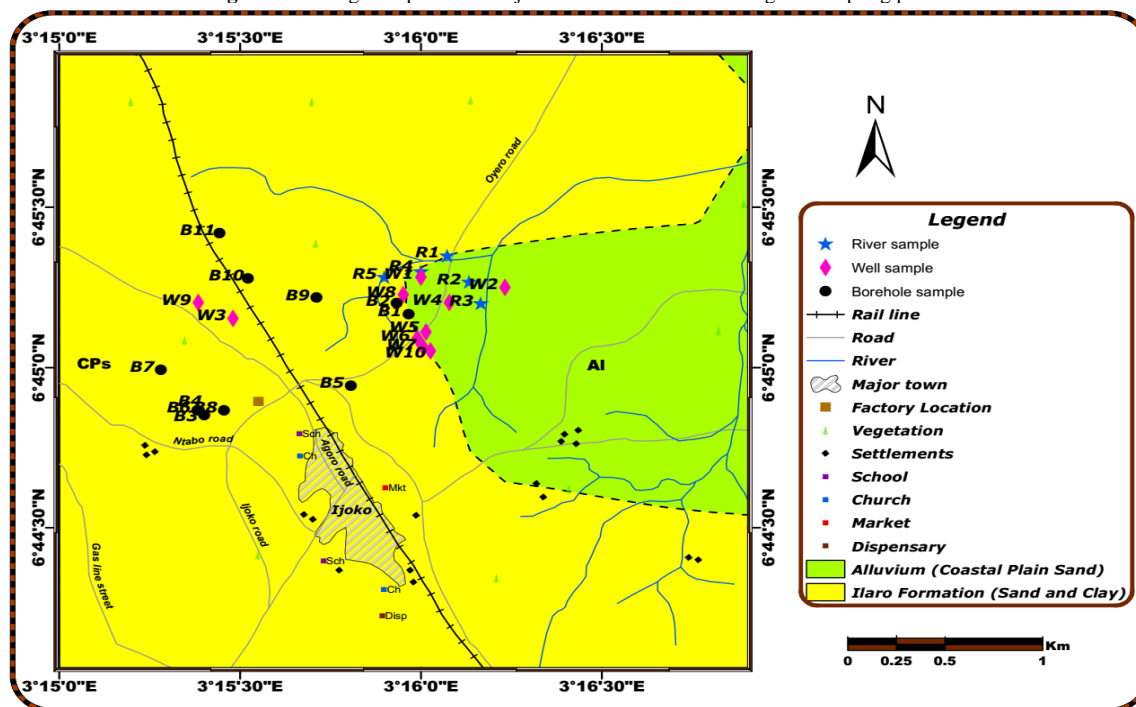


Figure-2. Geologic map extract of Ijoko and its Environs showing the sampling points



3. Materials and Methods

The principal features of water quality in the streams, lakes and rivers which is of utmost importance to the hydrologist is divided into three main groups; physical, chemical and biological characteristics.

The physical, chemical, biological characteristics of water determine its usefulness for domestic use, industry or agriculture. The study of water chemistry (water quality), gives important indications of the geological history of the area, the velocity and direction of water movement and the presence of hidden deposits.

Twenty-Six (26) water samples comprising of three (3) sources- hand-dug wells, boreholes and rivers, collected randomly from various locations were subjected to physical tests using the Milkauwee Meter to determine its electrical conductivity, concentration of total dissolved solid (TDS) and the hydrogen potential (pH). The result of the tests (in terms of ranges and averages) was compared with World Health Organization (WHO) and Standard Organization of Nigeria (SON) recommended standard for drinking water in order to determine the quality of the water. The water samples were also subjected to several hydrogeochemical analyses which includes analytical standard methods such as titrimetric (EDTA) and colorimetric for the anions and ICP-OES (Inductively Coupled Plasma-Optical Emission Spectroscopy) was used for analyzing the cations.

4. Results and Discussion

Assessment of the groundwater quality as carried out on the water samples were established through the physico-chemical analyses to determine the concentration of ions and quality of the groundwater from hand-dug wells, rivers and boreholes of Ijoko community in South western Nigeria are presented in [Tables 1 and 2](#) while [Table 3](#) shows the mean, range, standard deviation of each parameter and its comparison with the minimum permissible by [Standard Organisation of Nigeria \(SON\) \[9\]](#) and [WHO Guidelines for drinking water quality criteria \[10\]](#).

Table-1. Result of the physical characteristics of the sampled water at various points

Location	Sample ID	Description	pH	TDS (mg/L)	EC (mg/L)
1	R1	River	6.3	790	1230
2	R2	River	6.1	1250	1950
3	R3	River	6.84	350	590
4	R4	River	3.82	4570	7130
5	R5	River	4.04	2780	4350
6	W1	Well	3.56	2110	3300
7	W2	Well	4.56	1270	1980
8	W3	Well	4.8	140	210
9	W4	Well	5.52	760	1180
10	W5	Well	5.27	340	520
11	W6	Well	5.46	360	550
12	W7	Well	3.92	240	310
13	W8	Well	5.73	490	770
14	W9	Well	5.23	30	50
15	W10	Well	5.7	80	120
16	B1	Borehole	4.86	5460	8540
17	B2	Borehole	4.34	3200	5100
18	B3	Borehole	5.01	290	440
19	B4	Borehole	4.14	60	90
20	B5	Borehole	4.77	300	460
21	B6	Borehole	5.35	90	140
22	B7	Borehole	4.97	30	50
23	B8	Borehole	4.42	810	240
24	B9	Borehole	4.43	800	240
25	B10	Borehole	4.64	40	50
26	B11	Borehole	3.71	70	110

pH- Hydrogen Potential, TDS-Total Dissolved Solid, EC-Electrical Conductivity

Table-2. Result of Chemical Analysis of the sampled groundwater at various sampling points

Location	Sample ID	Description	Ca ²⁺ (mg/L)	Mg ²⁺ (mg/L)	K ⁺ (mg/L)	Na ⁺ (mg/L)	SO ₄ ²⁻ (mg/L)	HCO ₃ ⁻ (mg/L)	Cl ⁻ (mg/L)
1	R1	River	10.6	2.6	1.1	230	3	32	348.65
2	R2	River	7.9	3.6	1.5	600	2	20	846.73
3	R3	River	5.2	1.6	1.2	71.3	2	28	109.58
4	R4	River	28.7	12	6.7	1600	6	5	2380.8
5	R5	River	5.8	3.5	12	81.9	4	12	737.15
6	W1	Well	18.2	8.9	6.5	994	4	4	1016.07
7	W2	Well	12.1	4.3	2.7	662	4	12	936.38
8	W3	Well	3.1	3.27	3.81	22.36	1.57	122.01	72.01
9	W4	Well	3.14	1.43	1.42	147.56	1.71	76.25	432.18
10	W5	Well	1.79	0.81	2.51	79.87	0.01	152.54	180.01
11	W6	Well	3.48	0.95	1.32	80.1	0.5	122.26	216.34
12	W7	Well	0.96	3.17	5.81	46.57	0.07	274.58	86.4
13	W8	Well	4.71	1.26	0.89	6.8	1.07	152.53	270
14	W9	Well	3.1	3.27	3.81	22.36	1.57	122.03	72.02
15	W10	Well	37.68	1.29	6.32	9.99	0.01	152.5	72.01
16	B1	Borehole	39.7	17.9	7.5	2570	5	4	2291.15
17	B2	Borehole	24	9.2	7	789	6	4	1125.65
18	B3	Borehole	0.71	0.54	0.2	63.24	1.14	61	216.01
19	B4	Borehole	0.8	0.85	1.21	597	2.5	51.23	108.25
20	B5	Borehole	1.46	1.09	1.2	65.24	0.29	122.25	216.36
21	B6	Borehole	1.28	0.43	0.3	20.14	0.01	274.5	126.14
22	B7	Borehole	0.38	0.51	0.2	4.02	0.05	183.01	108.17
23	B8	Borehole	1.48	1.07	0.62	190.51	1.17	91.52	90.14
24	B9	Borehole	2.71	0.78	0.59	5.01	0.03	122.1	90.23
25	B10	Borehole	0.3	0.4	0.1	4.21	5.93	152.12	36.14
26	B11	Borehole	0.83	0.93	1.19	3.89	0.86	152.5	90.04

5. Drinking Water Quality

Drinking water quality has been established by many organizations which include the World Health Organization (WHO), which set up international standards for drinking water quality in 1993; Standard Organization of Nigeria (SON) standard for drinking water and EU directives of 1980 on quality of water intended for human consumption amongst others. These standards are widely used as consideration for drinking water quality and the results from the water sampled as interpreted in [table 3](#), comprises of the statistical interpretation such as the mean, standard deviation and range of each parameter in the study area and their comparison with World Health Organization (WHO) and Standard Organization of Nigeria (SON) standards.

5.1. Hydrogen Potential (pH), Total Dissolved Solid (TDS) and Electrical Conductivity (EC)

The pH of the water sampled which gives the degree of acidity or alkalinity of the water ranges from 3.56-6.84 with an average value of 4.9 thus making about 96% of the water sampled to be acidic since they exceed the maximum permissible by [Standard Organisation of Nigeria \(SON\) \[9\]](#) and [WHO Guidelines for drinking water quality criteria \[10\]](#) in potable groundwater.

The total dissolved solid (TDS) values for all the samples range from 30mg/L to 5460mg/L with a mean value of 1027.31mg/L. This is above the minimum permissible by SON and WHO with extremely high values recorded in samples R4, R5, W1, B1 and B2 which makes about 19% of the sampled water. This is indicative of more dissolved ions than as seen in the other locations.

Electrical conductivity (EC) which is a measure of the degree of the mineralization of the water and a measure of the total dissolved ionic components in the water and its electrical characteristics was also calculated for all the sampled groundwater and their values range from 50mg/L to 8540mg/L with mean value of 1526.92mg/L making 57% to exceed the desirable permissible by WHO for drinking water as seen in samples R1, R2, R3, R4, R5, W1, W2, W4, W5, W6, W8, B1, B2, B3 and B5.

5.2. Cation Concentrations in the Groundwater

The cations analysed for in the groundwater include sodium, calcium, magnesium and potassium.

The sodium (Na^+) concentration in the water collected from the various points have values ranging from 3.89mg/L to 2570mg/L with an average of 344.89mg/L exceeding the desirable permissible by [WHO Guidelines for drinking water quality criteria \[10\]](#) and [Standard Organisation of Nigeria \(SON\) \[9\]](#) which is 10mg/L and 200mg/L respectively. High concentration of Na^+ was recorded in R1, R2, R4, W1, W2, B1, B2 and B4 making about 31% of the sampled water.

Unlike the sodium ion concentration which is relatively high in most of the locations, Ca^{2+} , Mg^{2+} and K^+ concentrations in all the waters are below the minimum permissible by SON and WHO standards for drinking water with mean values of 8.47mg/L, 3.29mg/L and 2.99mg/L respectively as shown in [Table 3](#). Thus, reflecting that the water would have been safe for drinking but for the high concentration of Na^+ present in them.

5.3. Anion Concentrations in the Groundwater

The anions present in the water include Cl^- , HCO_3^- and SO_4^{2-} . High concentration of chloride ion (Cl^-) in the groundwater can be a resultant effect of weathering of rocks, infiltration from anthropogenic sources and industrial applications.

In the studied water samples, the chlorine concentration ranges from 36.14mg/L to 2380.8mg/L and averages 472.1mg/L. This is relatively higher than the minimum permissible by WHO and SON thereby, making the water unsafe for drinking. These high values are recorded in R1, R2, R4, R5, W1, W2, W4, W6, W8, B1, B2, B3, and B5, which makes 50% of the water sampled.

The SO_4^{2-} concentration ranges from 0.01mg/L to 6.0mg/L and averages 2.1mg/L. This is below the minimum permissible by WHO and SON standard for drinking water; likewise the HCO_3^- concentration which ranges from 4mg/L to 274.58mg/L and averages 96.38mg/L.

Also, [Tremblay, et al. \[11\]](#) considered that Cl^- content of 20mg/L belongs to uncontaminated groundwater while Cl^- greater than 40mg/L indicates salt water contamination. In addition to this, [Todd \[1\]](#) postulated that Cl^- in natural water is commonly less than 10mg/L especially in humid regions but in the study area, the concentration of the Chloride ion in the waters is relatively very high and can be regarded as contamination. This also agrees with [\[12\]](#) that Cl^- in excess of 50mg/L indicate salt water contamination.

Table-3. Comparison of Statistical Value with WHO and SON Standard.

Measured Parameters	Mean	Standard Deviation	Min (Mg/L)	Max (Mg/L)	Who (2006) Min. (Mg/L)	Who (2006) Max. Perm (Mg/L).	Son (2007) Max.Perm (Mg/L)	Limit Point
Ph	4.9	0.82	3.56	6.84	6.5	9.5	6.5-8.5	BELOW
TDS	1027.31	1417.42	30	5460	500	1500	500	ABOVE
EC	1526.92	2251.81	50	8540	400	1500	1000	ABOVE
Ca ²⁺	8.47	11.31	0.3	37.68	75	200	NA	BELOW
Mg ²⁺	3.29	4.13	0.4	17.9	40	150	0.2	BELOW
K ⁺	2.99	3.01	0.1	12	10	15	NA	BELOW
Na ⁺	344.89	587.86	3.89	2570	10	<20	200	ABOVE
SO ₄ ²⁻	2.1	1.98	0.01	6	150	250	100	BELOW
HCO ₃ ²⁻	96.38	77.6	4	274.58	VARIABLE	VARIABLE	NA	NA
Cl ⁻	472.1	626.75	36.14	2380.8	200	400	250	ABOVE

mg/L- Milligram per Litre, MIN-Minimum, MAX-Maximum, WHO-World Health Organization, SON-Standard Organization of Nigeria

5.4. Hydro-Chemical Facies

Extensive understanding of groundwater geochemistry involves the use of trilinear plotting system where the cations generally considered for this purpose are calcium, magnesium and potassium and the anions include bicarbonate, chloride and sulphate. This is because they are the most common constituents in unpolluted groundwater and chemical characteristics of most natural waters can be closely approximated by their relative concentration [13].

The major cations and anions such as Ca²⁺, Mg²⁺, Na⁺, K⁺, CO₃²⁻, HCO₃⁻, SO₄²⁻ and Cl⁻ (in meq/l) are plotted on Piper's trilinear diagram [14, 15].

The piper trilinear plot helps to distinguish different groundwater facies by dividing the diamond plot to different zones- CaCl₂, CaMgCl, CaHCO₃, NaCl, NaHCO₃ and Mixed CaNaHCO₃ facies.

The generated plot shown in Figure 3 indicate dominance of Na⁺ over the other metals and dominance of strong acid (Cl⁻) over the weak acid (HCO₃⁻) which is evidenced by the plot of the sampled groundwater at the right hand side of the diamond plot which falls within the Na-Cl water facies section which is indicative of high salinity.

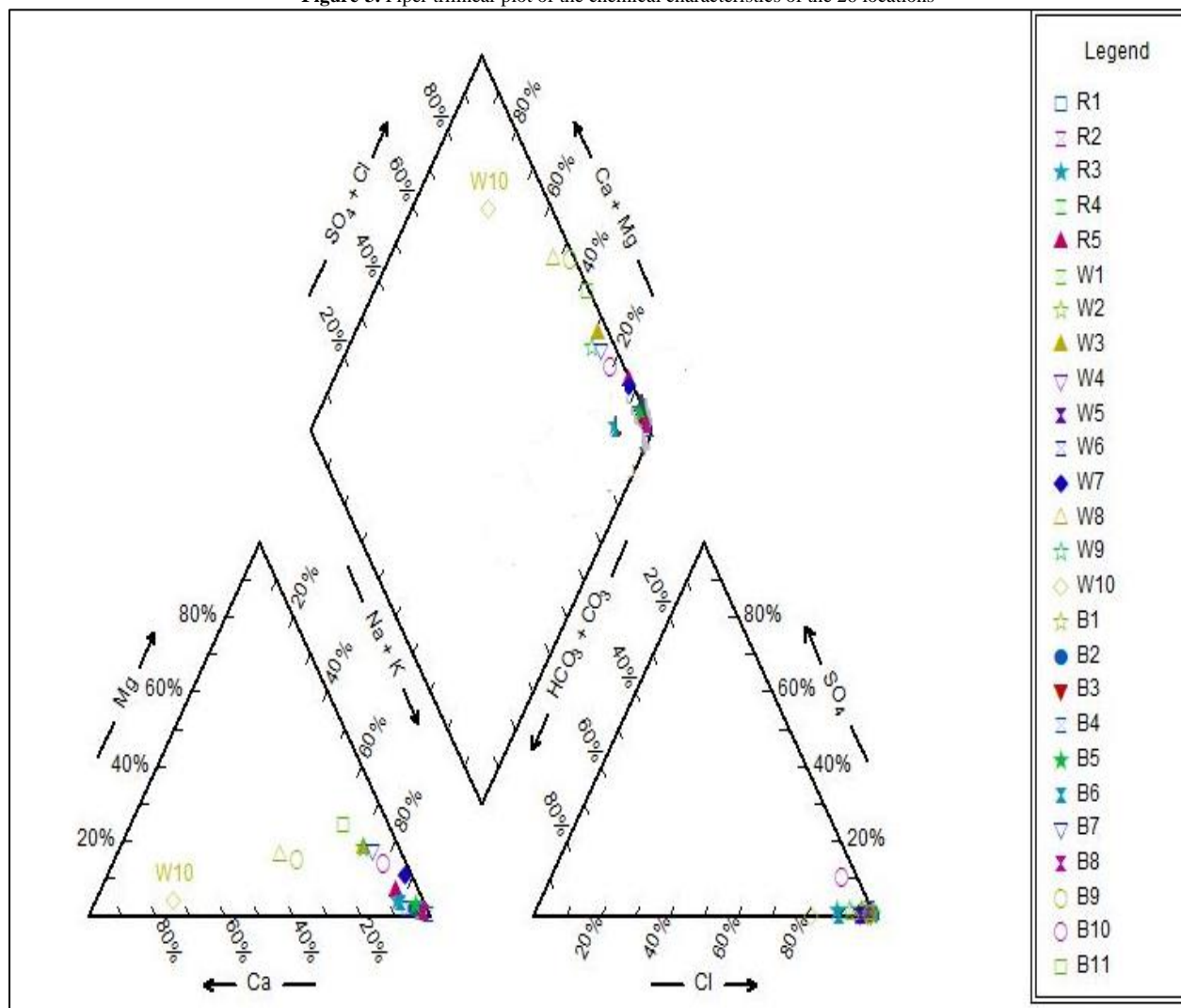
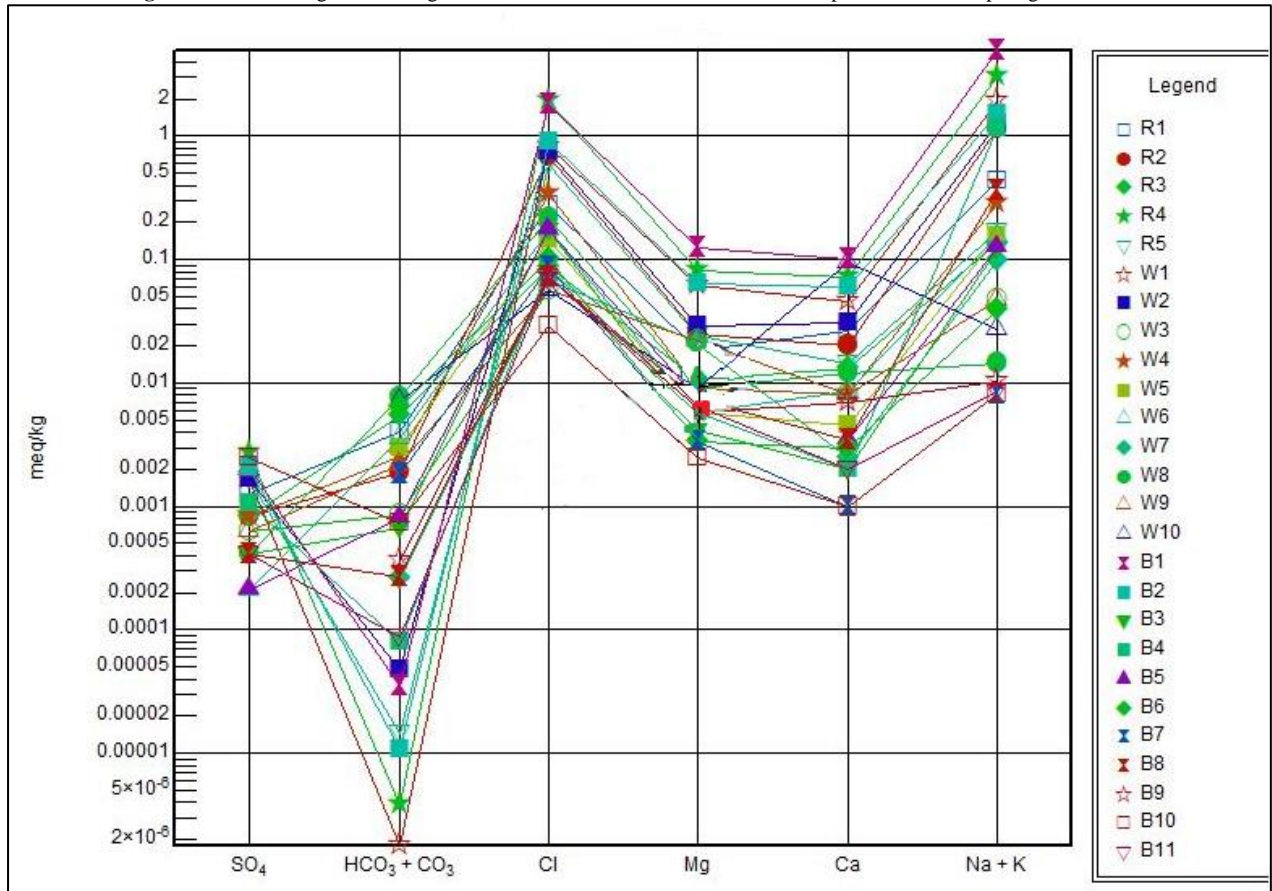
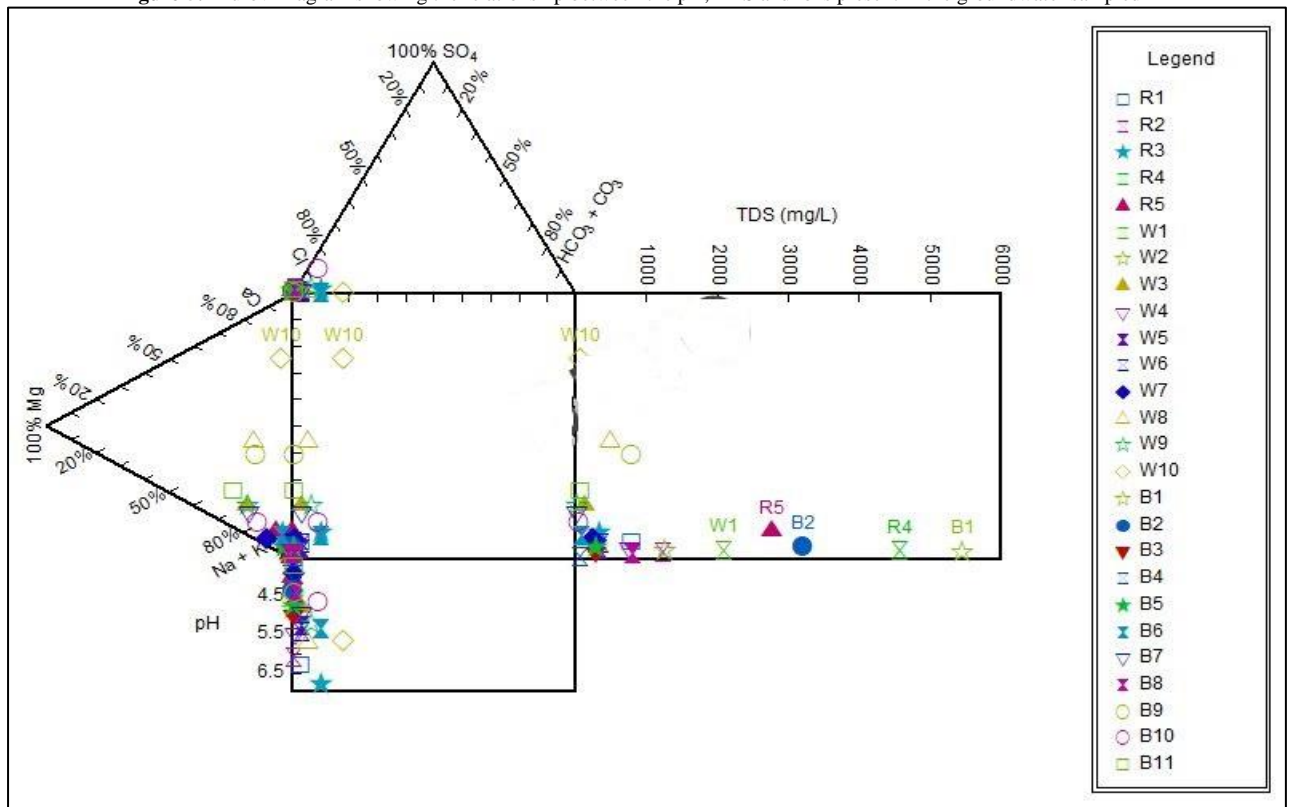
Figure-3. Piper trilinear plot of the chemical characteristics of the 26 locations

Figure-4. Scholler diagram showing the distribution and concentration of the ions present in the sampled groundwater

The scholler diagram generated in Figure 4, which is a plot that presents the average chemical composition of groundwater in terms of concentration and distribution of each samples show dominance of Cl^- and Na^+ in the waters. Thus, characterizing the ionic composition of the groundwater in the area to have cations and anions dominant in this order - $\text{Na}^+ > \text{Ca}^{2+} > \text{Mg}^{2+} > \text{K}^+$ and $\text{Cl}^- > \text{HCO}_3^- > \text{SO}_4^{2-}$ respectively.

Also, the Durov diagram generated (Figure 5) shows dominance of Cl^- and Na^+ indicating groundwater related to reverse ion exchange.

Figure-5. Durov Diagram showing the relationship between the pH, TDS and ions present in the groundwater sampled

6. Irrigation Characteristics

For water to be good for irrigation, its sodium content or alkali hazard is evaluated to determine its suitability. Four (4) main chemical parameters were employed in this regard and it includes EC (Electrical Conductivity), SAR (Sodium Adsorption Ratio), SSP (Soluble Sodium Percentage) and RSC (Residual Sodium Carbonate).

6.1. Sodium Adsorption Ratio (SAR)

The SAR is used to predict the degree of accumulation of excessive sodium in the water if any and the effect of which may change soil properties, reduce its permeability or change the soil structure [16]. The formula used in calculating this is stated below.

$$SAR = \{Na^+ / (\sqrt{Ca^{2+} + Mg^{2+}/2})\}$$

6.2. Soluble Sodium Percent (SSP)

The SSP was calculated because sodium reacts with soil to reduce its permeability. When it is being absorbed by clay particles, it displaces Mg and Ca ions thereby reducing the soil permeability and causing poor drainage. This was calculated using the following formula as expressed in meq/l.

$$\%Na^+ = \frac{(Na^+ + k^+) \times 100}{(Ca^{2+} + Mg^{2+} + Na^+ + k^+)}$$

Soils containing large proportions of sodium with carbonate as the predominant anions are termed alkali soil whereas if chloride or sulphate is the predominant cations, they are termed saline soil. Neither of which will support plant growth.

6.3. Residual Sodium Carbonate (RSC)

This is frequently used to assess the water quality used in irrigation. This is the determination of the amount of bicarbonate and carbonate in excess over alkaline earth elements (Ca + Mg). The resultant effect of which produces an alkali soil which gives burning effect on leaves of plants and reduces crop yield.

This is calculated using the following formula:

$$RSC = (CO_3 + HCO_3) - (Ca + Mg)$$

The SAR, SSP, and RSC generated from the anions and cations concentration are presented in Table 4 in meq/l unit.

Table-4. Calculated Irrigation Characteristics of the groundwater sampled in Meq/l

Location	Sample ID	Description	SSP	SAR	RSC
1	R1	River	92.55	16.37	-0.22
2	R2	River	97.12	44.25	-0.37
3	R3	River	87.16	6.99	0.066
4	R4	River	96.15	63.05	-2.35
5	R5	River	74.59	6.603	-0.38
6	W1	Well	95.59	47.56	-1.59
7	W2	Well	96.3	41.47	-0.77
8	W3	Well	60.75	2.103	1.573
9	W4	Well	94.81	17.27	0.974
10	W5	Well	92.31	12.39	2.344
11	W6	Well	91.52	9.789	1.751
12	W7	Well	76.62	5.125	4.189
13	W8	Well	43.29	0.717	2.16
14	W9	Well	60.75	2.103	1.573
15	W10	Well	15.75	0.435	0.509
16	B1	Borehole	96.65	84.75	-3.41
17	B2	Borehole	93.63	34.59	-1.9
18	B3	Borehole	96.8	13.71	0.92
19	B4	Borehole	99.33	110.3	0.729
20	B5	Borehole	92.59	9.911	1.84
21	B6	Borehole	88.34	3.919	4.4
22	B7	Borehole	70.82	0.997	2.939
23	B8	Borehole	97.69	29	1.337
24	B9	Borehole	48.47	0.688	1.801
25	B10	Borehole	77.35	1.177	2.445
26	B11	Borehole	48.22	0.693	2.381

Note: SSP- Soluble Sodium Percentage, SAR- Sodium Adsorption Ratio, RSC-Residual Sodium Carbonate

Table-5. Quality of water after USDA Salinity Laboratory (January 2006)

S/N	Tds (Mg/L)	Ec(Mg/L)	Salinity Class	Type of Water	Sample Id
1	<150	Below 250	Excellent or Low C1	Low saline water	W3, B4, W9, W10, B6, B7, B8, B9, B10, B11
2	150-500	250-750	Good or Medium C2	Moderately saline	R3, W5, W6, W7, B3, B5
3	500-1500	750-2250	Permissible or High C3	High salinity	R1, R2, W2, W4, W8
4	1500-3000	Above 2250	Unsuitable or Very High C4	Very High salinity	R4, R5, B1, B2, W1

The SAR for the groundwater sampled ranges from 0.44meq/L-110.26meq/L as shown in [Table 3](#) and when classified after [Richards \[17\]](#) in [Table 6](#), more than 40% of the sampled water fall within the range of moderately suitable to unsuitable for irrigation purpose.

Table-6. Classification of irrigation water based on SAR (Richard, 1954)

S/N	Types of Water and SAR value	Quality	Suitability for Irrigation	Sample ID
1	Low sodium water (S1) <10	Excellent	Suitable for all types of crops and all types of soils, except for those crops which are sensitive to sodium	R3,R5,W3,W6,W7,W8,W9,W10,B5,B6,B7,B9,B10 and B11
2	Medium Sodium water (S2) 10-18	Good	Suitable for coarse textured or organic soils with good permeability. Relatively unsuitable in fine textured soils.	R1,W4,W5,B3,
3	High Sodium water (S3) 18-26	Fair	Harmful for almost all types of soil and requires good drainage, high leaching gypsum added.	Nil
4	Very High Sodium water (S4) Above 26	Poor	Unsuitable for Irrigation	R2,R4,W1,W2.B1,B2,B4 and B8

From the SSP calculated in all the sampled water, 85% of the samples have sodium contents exceeding the 60% permissible limit for water suitable for irrigation according to [Wilcox \[18\]](#). This as shown in [Table 7](#) indicates that the water falls within the range of doubtful to unsuitable for irrigation purpose.

Based on the residual sodium carbonate calculated, only samples W7, B6 and B7 are unsuitable for irrigation purpose ([Table 8](#)).

Table-7. Suitability of Irrigation water based on Sodium Percent [\[18\]](#)

%Na	Suitability for Irrigation	Sample ID
<20	Excellent	W10,
20-40	Good	Nil
40-60	Permissible	W8, B9 and B11
60-80	Doubtful	R5, W3, W7, W9, B7, B10
>80	Unsuitable	R1, R2, R3, R4, W1, W2, W4, W5, W6, B1, B2, B3, B4, B5, B6 and B8.

Table-8. Water quality based on RSC [\[17\]](#)

S/N	RSC	Remarks on Quality	Sample ID
1	<1.25	Safe/Good	R1, R2, R3, R4, R5, W1, W2, W4, W10, B1, B2, B3, B4,
2	1.25-2.50	Marginal/doubtful	W3, W5, W6, W8,, W9, B5, B8, B9, B10, B11
3	>2.50	Unsuitable	W7, B6, B7,

7. Conclusion

The physico-chemical characteristics of water were carried out in the study area to know its viability as potable water and for irrigation purpose.

The result of the physical parameters measured such as the pH reveal that 96% of the water samples are acidic in nature, while the Electrical conductivity shows that 57% of the water sampled has values above the desirable limit for a good drinking water.

Though excess chloride ions in water may not pose any health risk to consumers; however, high concentrations of chloride and sodium ions in water may interact to form sodium chloride which could impart a salty taste to the water [Cobbina, et al. \[19\]](#) and a negative effect on the consumer. This effect includes chronic heart failure brought

about by high blood pressure in adults and severe gastrointestinal infections in infants which can bring about permanent neurological damage [10].

In the studied sample, the concentration of all the cations and anions fell below the desirable limit approved by WHO and SON except in the sodium and chloride ions where extremely high concentration were recorded in samples collected from rivers (R1, R2 and R4), 2 shallow hand-dug wells (W1 and W2) and boreholes (B1 and B2).

The hydro-geochemical facies generated from the diamond plot and scholler diagram reveal the cations and anions plotting within the Na-Cl facies and in ionic order of dominance as $\text{Na}^+ > \text{Ca}^{2+} > \text{Mg}^{2+} > \text{K}^+$ and $\text{Cl}^- > \text{HCO}_3^- > \text{SO}_4^{2-}$ respectively.

The irrigation parameters calculated also reveal the presence of high concentration of sodium in 85% of the water sampled; which is above the permissible limit for irrigation thereby making the water unsuitable for irrigation purpose.

In view of this, not all the water sampled has the required quality for drinking and irrigation purpose.

Recommendation

Boreholes are the most reliable source of groundwater in the area since only 3 borehole samples out of 11 recorded high concentrations of sodium and chloride ions, it is recommended that more boreholes should be drilled instead of hand-dug wells.

Acknowledgements

Appreciations go to the HRM of Ogba-Iyo, Chiefs and Community, who through their unflinching support gave us approval and access to carry out the water sampling.

References

- [1] Todd, D. K., 1980. *Groundwater Hydrology*. 2nd ed. New York. USA: John Wiley and Sons. pp. 494-520.
- [2] Jones, N. A. and Hockey, R. D., 1964. *The geology of part of Southwestern Nigeria*. Geological survey of Nigeria Bulletin, p. 31.
- [3] Ogbe, 1970. *Stratigraphy of strata exposed in the ewekoro quarry, Southwestern Nigeria in: T.F.J dessauvage and whiteman (eds) african geology*. Nigeria: University Press. pp. 305-322.
- [4] Omatsola, M. E. and Adegoke, O. S., 1981. "Tectonic evolution and cretaceous stratigraphy of Dahomey Basin." *Journal of Mineral Science*, vol. 18, pp. 30-137.
- [5] Whiteman, A. J., 1982. *Nigeria: Its petroleum geology, Resources and potentials* vol. 1. London, U.K.: Graham and Trotman. p. 176.
- [6] Adegoke, O. S., 1969. "The eocene stratigraphy of Southern Nigeria." *Mem. Bur. Rech. Geol. Min.*, vol. 69, pp. 23-49.
- [7] Idowu, J. O., Ajiboye, S. A., Ilesanmi, M. A., and Tanimola, A., 1993. "Origin and significance of organic matter of oshosun formation, Southwestern Nigeria." *Journal of Mining Geology*, vol. 29, pp. 9-17.
- [8] Okosun, E., 1990. "A review of the cretaceous stratigraphy of the dahomey embayment, west Africa." *Cretaceous Research*, vol. 11, pp. 17-27.
- [9] Standard Organisation of Nigeria (SON), 2007. *Standard for drinking Water Quality*. NIS, pp. 345-350.
- [10] WHO Guidelines for drinking water quality criteria, 1996. *Health criteria and other supporting information*. 2nd ed. vol. 2. Geneva: World Health Organization. pp. 281-308.
- [11] Tremblay, J. J., D'Cruz, J., and Anger, H., 1973. "Salt water intrusion in the summerside area, P.E.I. Groundwater." vol. 11, pp. 21-27.
- [12] Harris, L. D., 1967. "Geology of the I.S. Bales well, lee county, virginia. Acambrian and ordovician test: Kentucky geological survey, ser." *10m Spec. Pub.*, vol. 14, pp. 50-55.
- [13] Hem, J. D., 1970. *Study and interpretation of the chemical characteristics of natural water*. 2nd ed., p. 363.
- [14] Piper, A. M., 1944. "A graphical procedure in the chemical interpretation of groundwater analysis. Trans. American." *Geophysics Union*, vol. 25, pp. 914-928.
- [15] Piper, A. M., 1953. *A graphic procedure in the geochemical interpretation of water analysis*. U.S. Geological Survey, Groundwater Note, pp. 12, 63.
- [16] Kelly, W. P., 1957. "Adsorbed sodium cation exchange capacity and percentage sodium adsorption in Alkali Soils." *Science*, vol. 84, pp. 473-477.
- [17] Richards, L. A., 1954. *(U.S. Salinity laboratory) diagnosis and improvement of saline and Alkaline Soils*. US Department of Agriculture Hand Book.
- [18] Wilcox, L. V., 1955. *Classification and use of irrigation waters* vol. 969. Washington DC, USA.: US Department of Agriculture Circular. pp. 1-19.
- [19] Cobbina, S. J., Nyame, F. K., and Obiri, S., 2012. "Groundwater quality in the sahelian region of Northern Ghana, West Africa." *Res Journal of Environmental and Earth Sciences*, vol. 4, pp. 482-491.