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An Investigation on Groundwater Chemistry from Geologic Controls on Water Sources around Ikare – Akoko Area, Southwestern Nigeria

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Abstract
The study area, Ikare and its environ is located in Akoko North East Area of Ondo State, Southwestern Nigeria. It lies between longitude $5^{0}45^{I}E$ *and* $5^{0}52^{I}E$ *and latitude* $7^{0}31^{I}N$ *and* $7^{0}35^{I}N$*. It covers an estimate area of about* $30km^{2}$ *with prominent settlements like Ikare, Ugbe, Iboropa and Arigidi. The study area is very accessible (roads and footpaths) making close observation of hand-dug wells, boreholes and surface waters easier. The geology of Ikare-Akoko area from field work shows that it lies within the Migmatite-Gneiss-Quartzite complex of the basement complex of south-western Nigeria.*
A total of thirty (30) water samples obtained from hand-dug wells, boreholes and surface waters within the three rock types were analysed for their physico-chemical properties. This is aimed at assessing their quality and usability as some physical and chemical parameters show average values. Statistical analysis using the Principal Component Analysis indicates that Ca, Cl, Conductivity and Fe are the major components that determine the groundwater chemistry in the study areas. Two water types dominant in the study areas include sodiumand calcium bicarbonates.They reflect effects of bedrock lithologies and base exchange processes from geologic controls on the chemistry of water sources in the areas.
Geophysical applications needed in determining the water yield in the area.

Keywords*:* *Base exchange, Geologic controls, Geochemistry, Groundwater*

1. Introduction

Groundwater geochemistry has become of great significance in recent times since groundwater has progressively become the most common source of potable water supply. The high demand for water to cater for domestic, industrial and agricultural purposes in Ikare and its environs is due to the fact that water is an important part of the earthly environment, covering about three-quarter (3/4) of the earth's surface.

Groundwater has got its own health and acceptability problems based on concentration levels for certain chemical parameters (Freeze and Cherry, 1979). It is therefore important to understand the toxicity, mobility and essentiality of chemical elements in groundwater particularly Zn, Cu, Mn and Pb that are potentially toxic. Others like F and Fe may give rise to health problems due to their deficiency in water. It is consequently important to understand groundwater characteristics within the study area with regard to flow patterns, distribution and chemistry (Lloyd, 1985).

Abundant surface water and groundwater exist in Southwestern region of the country lying within the tropical rainforest zone. The study area lies within the Southwestern basement complex of Nigeria. The development of groundwater resource in the region has been relatively slow. It has boreholes producing somewhat variable and unpredictable yields. Apart from the surface water in reservoirs formed by dams that serve the community, the state government has embarked on the development of potable groundwater for use by the numerous communities in the study area.

It is observed that the study area is well drained by rivers and streams found flowing through joints, faults and crevices within the rocks for accumulation. Although, there is no up-to-date data on the daily water supply, demand and use, observation have shown that domestic needs account for a substantial part of the water consumption in the area. Since the quality of groundwater is affected by the characteristics of the environment of circulation and occurrence, such sources are invariably exposed to anthropogenic pollutants. Okagbue (1988) has amply stated that a complete appraisal of available water resources in any area is commonly accomplished when aspects of water quality are included.

Hence, the need to evaluate both the groundwater and surface water resources in the area becomes necessary. It is particularly aimed at determining the quality and usability of the water in the area, in addition to ascertaining possible pollutants and ways to ameliorate their effects. Generally, groundwater at the discharge zones tend to have higher mineral concentration levels compared with that at the recharge zones, an effect generated from prolonged contact with the geological factors (Walton, 1970; Todd, 1980).

2. The Study Area

The study area, Ikare and its environ is located in Akoko North East Local Government Area of Ondo State, Southwestern Nigeria. It lies between longitude $5^0 45^I$E and $5^0 52^I$E and latitude $7^0 31^I$N and $7^0 35^I$N. It covers an estimate area of about $30km^2$ with prominent settlements like Ikare, Ugbe, Iboropa and Arigidi. The study area is very accessible and linked with motorable road network. There are also footpaths which make close observation of hand-dug wells, boreholes and surface waters easier.

Ikare Akoko is geographically located in the North Senatorial district of Ondo State and surrounded by Okeagbe in the North West, Oka Akoko in the Southwest and Isua in the Southeast all within the Akoko region. The study area shares very close boundary with immediate communities like Iboropa, Arigidi, Ugbe and Akungba Akoko respectively. (Map of Ondo State).

The study area doubles as the administrative headquarter of the Local Government and the commercial nerve centre for all surrounding communities. These surrounding communities are well forested with woodland type of vegetation with both indigenous and exotic coniferous trees and are generally regarded as a highly productive agricultural zone in Ikare Akoko area.

Although the land potential in the area has not been fully exploited. There is a wide range of food crops being grown in the area such as sugarcane, cassava, okra, vegetables and cash crops like cocoa and kolanuts among others. The study area falls within the rainforest zone where leaves are evergreen during the rainy season and capable of shedding leaves during the dry season. The rainy season is experienced between the months of April and October while the dry season falls between November and March respectively.

The topography is that of a hilly environment, gently undulating and most of the valleys have flowing streams or rivers which drain into River Ose. The major rivers are Rivers Dada, Awara, Agbo, Omiri, etc. The channels of most of these rivers, especially Rivers Awara, and even some streams, exploit fractures and miniature faults, which could be recognized on aerial photographs as photo lineaments. The most prominent drainage pattern in this area is dendritic. Where gneissic rocks either migmatite or granite gneisses exist, trellis pattern is most prominent. Flow direction of Rivers Dada and Awara are prominent along weaker and fractured trends. The smaller rivers are rarely true flowing and usually flow into River Ose.

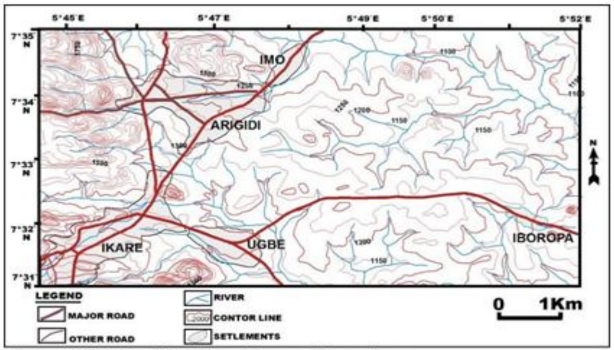


Figure 1: Topographical Map of Ikare and its environs.

Figure 1

3. Geological Setting

The local geology of the study area depicts Migmatite-Gneiss-Quartzite complex accounting for well over 90% of the Basement Complex outcrop in Ikare area. Four major rock group units (Rahaman and Ocan, 1988) were recognized within the complex. These are:

- Quartzo-feldspathic gneisses
- Pelitic gneisses
- Basic and ultrabasic rocks
- The felsic components.

Quartzo-feldspathic gneisses are by far the most abundant group of rocks within this area. In and around Ikare town they have been intruded by a relatively small amount of felsic components, represented by minor pegmatites and quartz rich quartzo-feldspathic veins some of which show intricate ptygmatic folds (as seen at a quarry behind Victory College, Ikare). Further north, the area becomes more migmatitic as the amount of intrusive material increases, finally leaving the quartzo-feldspathic gneisses as xenoliths of various sizes.

Pelitic gneisses outcrop as three mappable bands in Ikare area. The longest band outcrops from south of Ogbagi and extends through Ikare in an approximate east-west direction, for a distance of about 15km. Two other smaller bands have been mapped near Igashi village about 15kms (Southeast of OmuoEkiti) and about 3kms west of Okeagbe. All the three bands appear to be completely enclosed in the quartzo-feldspathic gneisses and this is indicative that the latter are of igneous origin.

The basic and ultrabasic rocks occur mainly as xenoliths in granitic gneisses and often as disrupted bands sometimes intricately folded together with the quartzo-feldspathic gneisses. The most common rock type present is amphibolites, but a small band of pyroxenite is found near Erusu village. Granitic gneisses outcrop as mappable units intercalated with the quartzo-feldspathic gneisses in the southern portion of the study area.

Generally, Ikare and its environment is underlained by Precambrian basement complex rock of Southwestern Nigeria. The lithological rock types include Grey gneiss, Granite gneiss, Charnockites, Granite, Quartzites, and Migmatite gneiss (Olanrewaju, 1988 and Owoyemi, 1996). These rocks form residual isolated hills and continuous ridges around Ikare area.

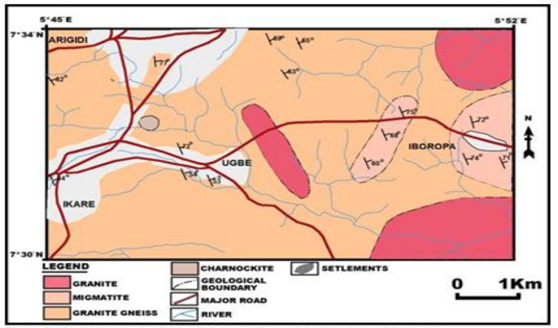


Figure 2. Geological map of the study area (Ikare, Arigidi,Ugbe and Iboropa).

Figure 2

4. Methods

Water samples were collected from 25 boreholes, 2 hand-dug wells and 3 surface waters making up a total of 30 water samples. Water samples were collected using half litre (1.5 litres) polyethylene bottles with cap stoppers (corks) aimed at preventing contamination. Hence, contaminants were prevented as sample bottles were cleaned with metal free nitric acid and then rinsed two to three times with distilled and deionised water in the field. Depth to water level and depth to bottom of each well were taken with the aid of meter tape with bob attached to its end to allow easy immersion.

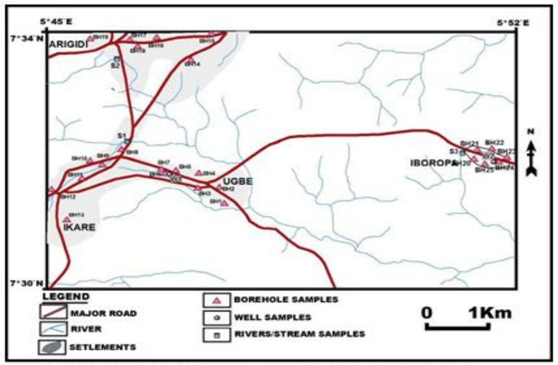


Figure 3. Sample locations within the study area (Ikare, Arigidi,Ugbe and Iboropa).

Figure 3

For every sample collected into the polyethylene bottles, labelling is ensured in respect to water type (HDW, BH and SW) and localities being Ikare, Ugbe, Iboropa and Arigidi respectively.

Samples from boreholes and surface waters were taken after the water was allowed to run (flow) for some time. One set of samples was filtered using 0.15μm filter membrane while 3ml of concentrated nitric acid was added to the second so as to prevent precipitation of hydrous oxides and absorption and at the same time inhibit the growth of microorganisms. The treated and untreated sample bottles were clearly marked for the determination of anionic and cationic parameters respectively. Samples were then kept in a cool place awaiting laboratory analysis. Total dissolved solids (TDS), conductivity (EC), pH and temperature were measured at the collection sites by use of HACH CND/TDS, T meter P/N 44600-00 and JENWAY model 4076 TDS/T meter.

Laboratory analysis involves tests on the chemical component of dominant aqueous ions and chemical properties of major constituents, mainly rock minerals capable of dissolving into the groundwater. Laboratory analysis was concentrated on the determination of some important and sine-qua-non anions and cations expected to be present in most waters, such as the case of Chlorine ion (Cl^-), involving the application of specific ion electrode method (Ionalyser Orion Research Model 801). Other anionic and cationic parameters tested for are Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^+), Potassium (K^+), Carbonate (HCO_3^-), Sulphate (SO_4^{2-}), Iron (Fe^{2+}) and Nitrate (NO_3^-). Parameters like Total Hardness (TH), Total Solid (TS), Temperature taken in laboratory (^0C), pH values, amount of oxygen, colour (in Hazan Unit), Turbidity, Odour, Calcium hardness, Electrical Conductivity (EC), Total alkalinity, Carbonate, Hydroxide, Phenolphthalein value, Methyl Orange value, Taste were also determined.

Metals were analysed by Atomic Absorption Spectrophotometry using direct aspiration method in which a Chemical Technical Analytical CTA-2000 Atomic Absorption Spectrophotometry was used.

The resultant data from both field and laboratory was interpreted using trilinear (Piper) diagrams and other statistical analyses such as Correlation analysis and Principal Component Analysis (PCA).

5. Results

Chemical analyses carried out in the study were basically on groundwater except for only three samples that were obtained from Rivers Awara, Agbo and Dada respectively (i.e. one sample from each river). The most abundant cation is Calcium (with a mean value of 28.3mg/l). Sodium is the second most abundant (with a mean value of 14.6mg/l). This is followed by Magnesium (Mg^+), Potassium and Iron respectively. For the anions, bicarbonate is the most abundant while Chloride, Sulphate and Nitrate in that order of abundance. The electrical conductivity levels range from 72µS/cm to 600µS/cm which were generally seen to be increasing with saline content (Cl^-) and increasing values of TDS and temperature. TDS values measured in the groundwater lay in the range of 20 – 525mg/l.

Two water groups were identified based on the characterization in the Piper trilinear diagram. This include Ca-(Mg)-HCO_3 and Ca-(Mg)-Na-HCO_3 reflecting the diverse effect of bedrock lithologies, weathering and base exchange processes. Hence, water types in the study area are sodium-bicarbonate and calcium-bicarbonate types.

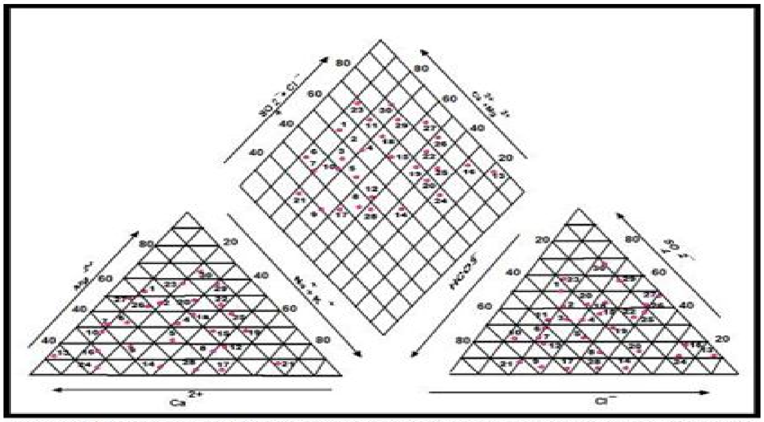


Figure 4: Trilinear piper diagram showing the chemical character of sampled water.

Figure 4

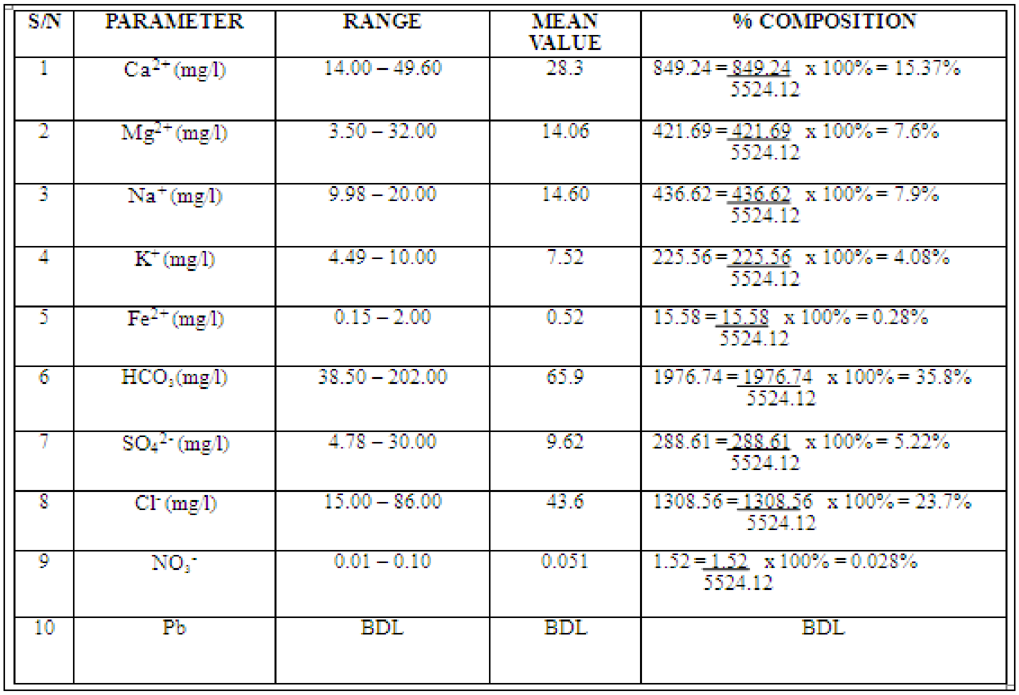
S/N	SAMPLE LOCATION	RESOURCE TYPE	SAMPLE NUMBER	pH VALUE	TEMP (^{0}C)	EC (us/cm)	TS (mg/l)	TH (mg/l)	SAR (mg/l)	TDS (mg/l)
1	Ugbe	BH	BH200	6.60	30.00	374	204	128	2.29	204
		BH	BH210	6.50	28.00	370	2234	74	2.26	180
		BH	BH220	6.80	30.00	372	1830	114	2.25	200
		BH	BH230	6.40	30.00	370	652	82	2.28	202
		BH	BH240	6.60	29.00	375	224	126	2.30	110
		BH	BH250	6.50	28.00	372	185	94	2.30	85
		BH	BH260	6.70	30.00	370	475	120	2.00	80
		HDW	HDW001	6.60	25.00	510	150.5	160	1.08	150
2	Ikare	SW	SW001	7.00	27.00	328	352.00	150	2.22	125.5
		BH	BH300	6.00	35.00	380	1084.00	138	1.05	525.0
		BH	BH310	6.10	34.00	370	300.00	135	1.08	400
		BH	BH320	6.00	35.00	200	245.00	105	1.00	250
		BH	BH330	6.10	35.00	248	262.00	120	1.50	500
		BH	BH340	6.20	36.00	209	275.00	116	1.04	250
		BH	BH350	6.30	35.00	300	324	135	1.06	300

3	Arigidi	SW	SW002	6.80	28.00	386	16940	174	2.07	425.5
		BH	BH400	6.60	37.50	310	340	88	2.06	86.0
		BH	BH410	6.55	36.00	150	375	78	2.04	80.0
		BH	BH420	6.60	37.00	182	426	65	2.00	82.5
		BH	BH430	6.50	35.00	195	189	80	2.08	85.0
		BH	BH440	6.60	38.00	236	320	84	2.01	80.0
		BH	BH450	6.60	37.00	182	215	66	2.04	86.0
4	Iboropa	BH	BH500	6.40	30.05	72	185	40	2.33	52.0
		BH	BH510	6.30	30.00	65	126	35	2.30	55.0
		BH	BH520	6.50	29.00	183	215	38	2.00	23.0
		BH	BH530	6.60	30.00	215	185	40	2.25	20.0
		BH	BH540	6.50	30.00	305	232	36	2.20	24.0
		BH	BH550	6.60	30.00	525	390	40	2.00	25.0
		SW	SW003	7.20	23.00	600	812	198	1.75	195
		HDW	HDW002	6.00	25.00	185	208	74	2.95	75.0

Table 1: Physicalparameters contributing to the groundwater quality in the study area

S/N	SAMPLE LOCATION	RESOURCE TYPE	SAMPLE NUMBER	LITHOLOGIC TYPE	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Na^+ (mg/l)	K^+ (mg/l)	HCO_3 (mg/l)	SO_4^{2-} (mg/l)	Cl^- (mg/l)	Fe^{2+} (mg/l)	NO_3^- (mg/l)	Pb (mg/l)
1	Ugbe	BH	BH200	Granite	36.60	10.00	20.00	5.00	94.90	4.89	50.00	0.25	0.10	BDL
		BH	BH210	Granite	35.20	11.00	18.99	4.98	96.05	4.97	48.90	0.24	0.09	BDL
		BH	BH220	Migmatite	34.40	10.00	19.50	4.99	96.00	5.05	49.90	0.25	0.10	BDL
		BH	BH230	Migmatite	34.30	16.00	19.90	5.00	96.00	4.99	50.00	0.25	0.08	BDL
		BH	BH240	Granite	34.30	21.00	19.00	5.02	94.82	5.00	48.90	0.26	0.10	BDL
		BH	BH250	Granite	34.40	10.00	20.01	4.89	95.88	4.98	50.00	0.25	0.10	BDL
		BH	BH260	Granite	34.30	25.00	20.00	5.00	96.00	5.00	48.90	0.27	0.10	BDL
		HDW	HDW001	Migmatite	49.60	22.00	10.00	5.00	78.00	30.00	75.00	0.25	0.05	BDL
2	Ikare	SW	SW001	Granite	31.20	14.10	15.00	10.00	202.00	10.00	46.50	0.20	0.05	BDL
		BH	BH300	Migmatite	31.30	31.00	10.00	9.98	40.00	15.00	55.00	0.15	0.05	BDL
		BH	BH310	Granite	30.28	12.02	9.98	10.00	38.90	14.98	54.00	0.15	0.04	BDL
		BH	BH320	Granite	32.18	28.50	10.00	9.50	39.90	15.00	55.00	0.18	0.05	BDL
		BH	BH330	Migmatite	30.33	20.60	9.55	10.00	40.00	14.99	56.00	0.15	0.04	BDL
		BH	BH340	Granite	31.30	18.80	10.00	9.98	38.90	15.00	54.00	0.18	0.05	BDL
		BH	BH350	Migmatite	30.28	32.00	9.98	10.00	39.00	14.89	50.00	0.15	0.05	BDL
3	Arigidi	SW	SW002	Granite	53.60	18.00	20.00	5.00	130.00	10.00	59.00	0.25	0.05	BDL
		BH	BH400	Migmatite	23.40	15.02	15.00	10.00	42.00	10.00	43.50	0.25	0.01	BDL
		BH	BH410	Granite	23.28	15.00	14.95	9.89	41.89	9.98	44.00	0.22	0.03	BDL
		BH	BH420	Migmatite	23.30	15.00	14.99	9.99	42.00	9.00	42.98	0.25	0.01	BDL
		BH	BH430	Migmatite	24.00	6.80	15.00	10.00	41.00	10.05	43.00	0.22	0.02	BDL
		BH	BH440	Migmatite	23.35	10.00	14.85	10.02	43.00	10.00	42.99	0.25	0.01	BDL
		BH	BH450	Migmatite	23.30	15.05	14.95	10.00	42.00	9.99	43.00	0.25	0.01	BDL
4	Iboropa	BH	BH500	Granite	14.00	4.00	15.00	5.00	42.05	10.00	15.50	0.25	0.01	BDL
		BH	BH510	Migmatite	14.40	5.00	10.00	4.98	39.00	5.00	15.49	2.00	0.03	BDL
		BH	BH520	Granite	14.30	3.50	10.00	4.85	38.50	4.98	15.00	2.00	0.03	BDL
		BH	BH530	Migmatite	14.28	3.60	9.98	5.00	38.90	4.99	15.50	1.98	0.04	BDL
		BH	BH540	Granite	14.26	3.80	9.99	4.49	39.00	5.00	15.00	2.00	0.03	BDL
		BH	BH550	Migmatite	15.00	3.90	10.00	5.00	39.05	4.78	15.50	1.98	0.02	BDL
		SW	SW003	Migmatite	44.80	6.00	20.00	12.00	102.00	10.00	86.00	0.25	0.07	BDL
		HDW	HDW002	Granite	44.80	15.00	20.00	10.00	70.00	10.00	20.00	0.25	0.10	BDL

Table 2: Chemical parameters contributing to the groundwater quality in the study area
BDL – Below Detection Limit (<0.01mg/l)



S/N	PARAMETER	RANGE	MEAN VALUE	% COMPOSITION
1	Ca^{2+} (mg/l)	14.00 – 49.60	28.3	$849.24 = \frac{849.24}{5524.12} \times 100\% = 15.37\%$
2	Mg^{2+} (mg/l)	3.50 – 32.00	14.06	$421.69 = \frac{421.69}{5524.12} \times 100\% = 7.6\%$
3	Na^{+} (mg/l)	9.98 – 20.00	14.60	$436.62 = \frac{436.62}{5524.12} \times 100\% = 7.9\%$
4	K^{+} (mg/l)	4.49 – 10.00	7.52	$225.56 = \frac{225.56}{5524.12} \times 100\% = 4.08\%$
5	Fe^{2+} (mg/l)	0.15 – 2.00	0.52	$15.58 = \frac{15.58}{5524.12} \times 100\% = 0.28\%$
6	HCO_3(mg/l)	38.50 – 202.00	65.9	$1976.74 = \frac{1976.74}{5524.12} \times 100\% = 35.8\%$
7	SO_4^{2-} (mg/l)	4.78 – 30.00	9.62	$288.61 = \frac{288.61}{5524.12} \times 100\% = 5.22\%$
8	Cl^{-} (mg/l)	15.00 – 86.00	43.6	$1308.56 = \frac{1308.56}{5524.12} \times 100\% = 23.7\%$
9	NO_3^{-}	0.01 – 0.10	0.051	$1.52 = \frac{1.52}{5524.12} \times 100\% = 0.028\%$
10	Pb	BDL	BDL	BDL

Table 3: Hydrochemicaldistribution of ions
BDL – Below Detection Limit (<0.01mg/l)

6. Discusssions

The use of Product Moment Correlation Coefficient as a basic geostatistical approach in correlating paired chemical parameters yielded no significant variations. Thus, suggesting that Ikare-Akoko area of the basement complex is generally underlain by two (2) groundwater fields. Hence, five (5) factors were extracted from the PCA analysis on the groundwater physico-chemical parameters as shown in Table 4.

Variable	Community	Factor	Eigen Value	% of Variance	Cumulative %
Ca^{2+}	1.00	1.00	2.45	20.41	20.41
Cl^{-}	1.00	2.00	2.08	17.33	37.72
Cond	1.00	3.00	1.68	14.00	51.74
Fe^{+}	1.00	4.00	1.28	10.66	62.40
HCO_3^{-}	1.00	5.00	1.06	8.83	71.23
K^{+}	1.00	6.00	0.89	7.41	78.64
Mg^{2+}	1.00	7.00	0.67	5.60	84.24
Na^{+}	1.00	8.00	0.64	5.33	89.57
NO_3^{-}	1.00	9.00	0.50	4.26	93.73
SO_4^{2-}	1.00	10.00	0.45	3.80	97.53

Table 4: Principal component analysis of the groundwater data

Results of the Principal Component analysis and Correlation analysis between different months around Ikare-Akoko area where water samples were collected as shown in the table above depicts loading for the rotated component matrix, eigen values for each component, percentage of variance and cumulative percentage of variance. This is explained by each component indicating the portion of variance of each variable controlled by the set of components.

Variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Ca^{2+}	0.01	-0.12	0.34	-0.12	-0.04
Cl^-	0.21	-0.05	0.14	0.10	-0.13
Cond	0.01	0.30	0.09	-0.06	0.00
Fe^+	0.20	0.01	-0.26	0.12	-0.12
HCO_3^-	0.21	0.22	-0.10	0.01	0.26
K^+	-0.13	0.32	0.02	0.11	0.22
Mg^{2+}	0.07	-0.05	0.32	0.10	-0.32
Na^+	0.05	-0.04	0.00	0.55	0.02
NO_3^-	0.26	-0.08	-0.10	0.15	0.32
SO_4^{2-}	-0.15	0.09	0.23	-0.10	0.25

Table 5: Principal component scores for the groundwater data

The first principal score accounted for 20.41% of the total variance, showing positive loading for Cl. Significant positive loadings were also seen for Fe, NO_3^- and HCO_3^- while Zn, SO_4, K and Mg show negative loadings. Principal score above reflects the chemical conditions of deposition for the sedimentary rocks in which evaporation played a vital role (resulting in deposition of halite).

The second Principal Score accounted for 17.33% of the total variance, showing positive loading for K and total ionic concentration. Hence, Ca, Cl, Conductivity and Fe have been observed to be the principal components that determine the groundwater chemistry in the study area. Other variables like HCO_3^-, K, Mg, Na and NO_3 contribute but to less extent. SO_4^{2-} and Zn are rather insignificant. Ca in these waters occurs as Ca^{2+} and $CaCO_{3(aq)}$ with the former having high concentrations. Ca and HCO_3 ions are the most abundant in groundwater of these area thus $CaHCO_3$ waters. Fe is suspected to exist as $Fe(OH)_4$ which is one of the principal variables in the determination of water chemistry in this area is generally derived from the Schist belt metasediments and also from the extensive migmatite gneiss, quartzo-feldspathic gneiss which make up the bulk of the geology of the study area in the basement complex. Ca^{2+} ions may thus be derived from such minerals like pyroxenes $(CaMgFeAl)_2(SiAl)_2O_6$, apatite $Ca_5(PO_4)_3(F, Cl, OH)$, Calcite $CaCO_3$, fluorite CaF_2 and montmorillonite.

Fe occurrence in these waters can be highly attributed to geological influence. The extent of laterites and lateritic soils might well suggest an answer to the Fe levels. Fe is traced to the presence of minerals like hematite (Fe_2O_3), limonite [$2Fe_2O_3(3H_2O)$], siderite (Fe_2CO_3) and mainly goethite [$Fe(OH)_4$] in which most iron is suspected to exist in these waters especially in colloidal form.

HCO_3^- ions could be attributed to minerals like calcite and siderite. Its presence and content is also influenced by biota through bacterial activities within the soil.

Conductivity is a function of TDS, which is highly influenced by temperature and pH.

Potassium and Sodium salts are highly soluble in water and waters in the study area help in fertilizing crops grown by peasant farmers in the study area.

The daily requirement for iron in human individuals is 1 – 2mg/l but the intake of larger quantities may be required If poor absorption occurs (WHO, 1982). The iron standard given for domestic and drinking water (300μg/l) is meant to prevent objectionable tastes or laundry staining and is therefore of aesthetic rather than toxicological significance. Iron at high concentrations is toxic to livestock by interfering with the metabolism of phosphorus (Camp, 1963).

7. Conclusion

The study has established that double (2) groundwater fields underlie the entire Ikare-Akoko area. Groundwater of this area is of bicarbonate types. Ca, Cl, total ionic concentration (dominated by Mg, K), Fe are the major principal components that determine the groundwater chemistry in this area. Geological and climatic factors have determined either directly or indirectly the type and content of the chemical constituents of the water in the area as well as their distribution.

Most of the weathered and fractured granite occurring in this area are the best potential aquifers. It was observed that recharge occurs locally in all parts of the study area where rocks of favourable permeability outcrop and where rainfall is substantial. The amount of water that is held by a given formation is however dependent on the amount of groundwater recharge and the extent of permeable rock exposed (Matthess, 1982). Local fissuring and extensive weathering within the rocks also form important groundwater aquifer zones for tapping into wells for potable water. The depths of water as evidenced in the geologic borehole logs and completion records indicate a groundwater profile that is closely linked to the topography of the study areas.

Iron concentration levels recorded for most of the water samples collected within the study area falls within permissible range. Except for some cases where iron concentration exceeds permissible range, which is linked to geological influences creating excess of lateritic soils within such environment. Also may be attributed to high content of hematite (Fe_2O_3), limonite [$2Fe_2O_3(3H_2O)$] and siderite (Fe_2CO_3) among others.

Thus, the water quality in the study area is generally acceptable as its usability for domestic, industrial and agricultural purposes are highly recommended.

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