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Hydrogeochemical investigation of surface water and groundwater around Ibokun, Ilesha area, southwestern Nigeria

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Abstract

In the Ibokun area of the Ilesha schist belt of southwestern Nigeria, the dominant rock types are granite gniess and amphibolite. The granite gneiss is medium to coarse grained, with lineation marked by alignment of biotite and microcline porphyroblasts. The amphibolite is commonly massive to weakly foliated, consisting to bluish-green to yellowish-green to sheaf-like aggregate of hornblende set in a fine grain matrix of tabular plagioclase. A total of 25 water samples, obtained from both groundwater and surface water sources in sites within the two dominant tock types, were analysed for their physico-chemical characteristics with the aim of assessing their quality and usability.

Result of some physical and hydrochemical parameters show average values of 7.83pH, 177.40mg/1 TDS; 30.86mg/1 ca^{2+}, 10.11mg/1 Na^+; 14.79mg/1 K^+, 4.36mg/1 Mg^{2+}, 29.59mg/1, HCO^-_3; 25.67mg/1 $C1^-$, 0.17 mg/1 Fe^{2+}, 4.74 mg/1 NO^-_3 and 318.22ms/cm conductivity. The water hardness and sodium absorption ratio (SAR) are respectively 11.71 mg/1 and 0.72. The total hardness, HCO^-_3 and Ca^{2+} are higher in the groundwater than the surface water, while NO^-_3, Mg^{2+} and conductivity are comparatively higher in the surface water than the ground water.

Statistical analysis, using the product-moment coefficient of correlation, indicate positive correlation between the following pairs of parameters: Total Hardness and TDS (r = 0.70); Na^+ and K^+ (r = 0.69); TDS and Ec (r=0.60). Weaker correlations were obtained between Ca^{2+} and HCO_3^- (r = 0.51); Ca^{2+} and Mg^{2+} (r = 0.36) while very weak correlations were observed between pH and TH (r = 0.22) and pH and $C1^-$ (r = 0.10).

Four water groups were identified, based on characterization in the Piper trilinear diagram. These include Ca – (Mg) – Na – HCO_3, Ca – Na – C1 – (SO_4) – HCO_3, Ca – (Mg) – HCO_3 and Na – (K) – Cl – SO_4. They reflect diverse effects of bedrock lithologies, base exchange processes, precipitation and weathering.

In general, both water sources are slightly alkaline. They have low sodium hazard, with SAR and other related parameters such as pH, NO^-_3 and Fe^{2+} falling within the permissible limits for potable water. The sources are generally suitable for both domestic and agriculture uses requiring minor treatments.

Introduction

Water is an important part of the earthly environment, covering about ¾ of the earth's surface. It occurs as surface water in streams, rivers, lakes and the worlds' seas and oceans and as groundwater, when it accumulates beneath the ground. Throughout the history of humanity, water has always sustained life and communities and the quality of available water is essentially an index of the living standard.

Abundant surface water and groundwater exist in southern Nigeria, particuarly in the southwestern region lying within the tropical rainforest zone. In the Ibokun district within the Ilesha schist belt of the basement complex of southwestern Nigeria, the development of groundwater resource has been relatively slow, with isolated 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 its numerous rural communities. Again, it is remarkable that the area is well drained of rivers and streams flowing through joints, faults and channels within the rocks.

Although, there is no up-to-date data on the daily water supply, demand and use, empirical observations have shown that domestic needs, account for a substantial part of the consumption in this area. This is due to limited number of gigantic factories, which would otherwise require substantial quantities of water. As the government is unable to meet the ever-increasing water demand, inhabitants have had to look for alternative sources such as streams, rivers and shallow handbug wells and boreholes.

Since the quality of water is affected by the characteristics of the environment of circulation and occurrence, such sources are invariably exposed to anthropogenic and industrial 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. Consequently, this study is borne-out of the need to evaluate both the ground water and surface water sources in the area. It particularly aims at determining the quality and usability of the water in addition to ascertaining possible pollutants and ways to ameliorate their effects.

Location and geology of the study area

The study area is about 20km north of Ilesha, and lies between latitudes 7°48'N and 7°50'N and longitude 4°42'E and 4°46'E (Fig. 1). It covers an area of about 68km² with prominent settlements such as Owode, Ilasa, Ikinyinwa, Ajebandele, Itiyo, Oloburo and Ipetu-Ile.

The area belongs to humid tropical climate, which is characterized by alternating wet and dry season. The wet season usually lasts from April to October and is dominated by heavy rainfall, while the dry season covers from November to March. The annual rainfall is about 1500mm

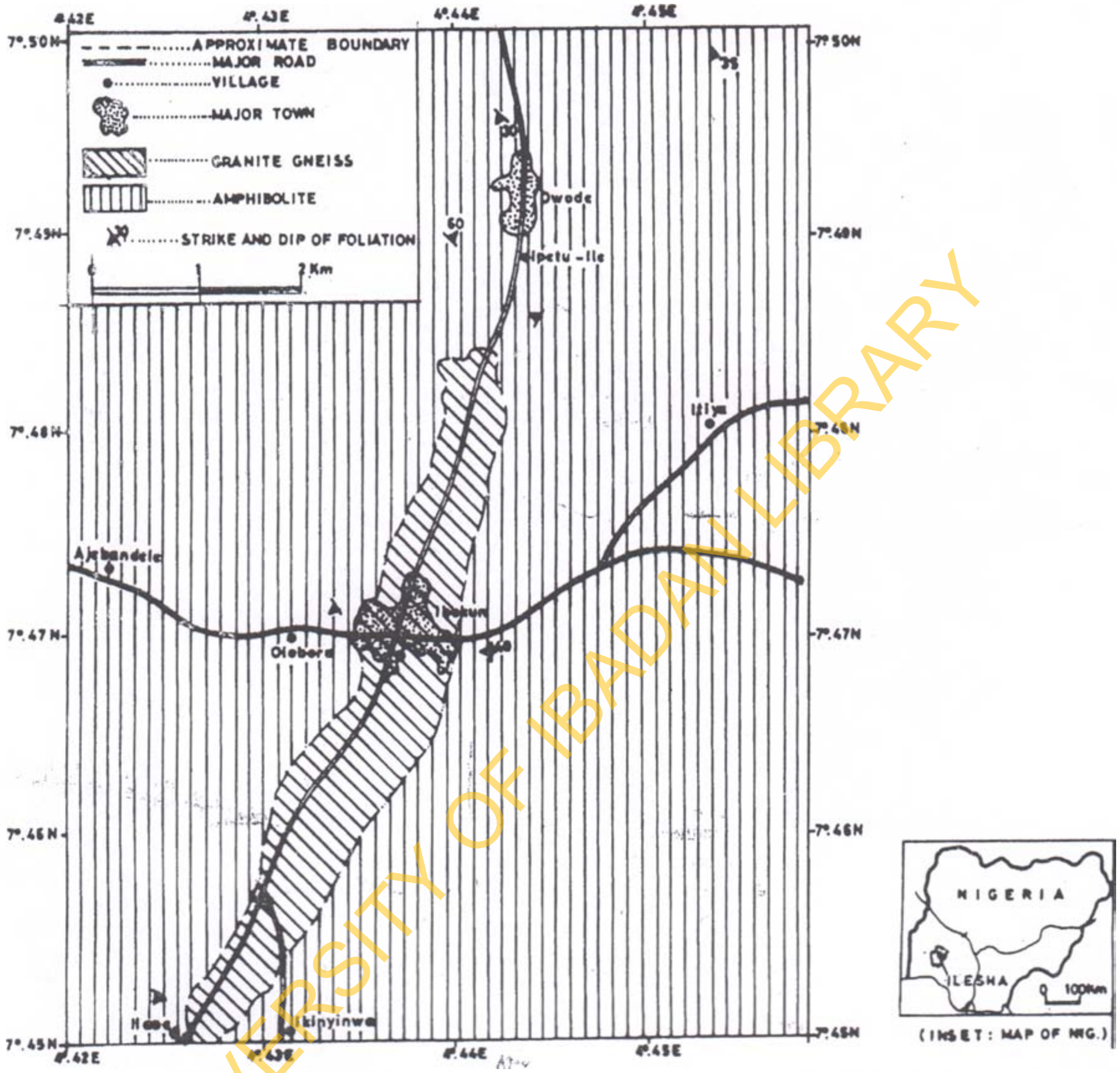

Fig. 1. Geological map of Ibokun and environs (adapted from Geological Survey of Nigeria, 1952)

while the average annual temperature is 26.6°C. (Duze and Ojo, 1982). High humidity (generally above 80%) and long wet season ensures adequate supply of water and continuous presence of moisture in the air.

The surface water resources in Ibokun district consist of several rivers and streams, which flow southwards in dendritic pattern. Some of the Rivers are Oloyo, Oyile, Oshun Doko and Ayeye (Fig. 2); and their flow directions are generally concordant of the strike of foliation and joints of the bedrocks.

They are all tributaries of River Oshun, a major and extensive river that is beyond the study area. The groundwater supplies are mainly from the hand-dug wells, with only one source from borehole reservoirs while fractured basement and joints constitute the aquifer materials for the borehole.

The area occurs within the Ilesha schist belt of the southwestern part of the basement complex of Nigeria. The schist belt comprises predominantly low to medium grade metasediments that are intimately associated with subordinate mafic-bodies, and are commonly flanked by rocks of the migmatite-gneiss suite. (Jones and Hockey, 1964; Rahaman, 1976; Turner, 1983; Elueze, 1986; 2000).

However around Ibokun, the dominant rocks are granite

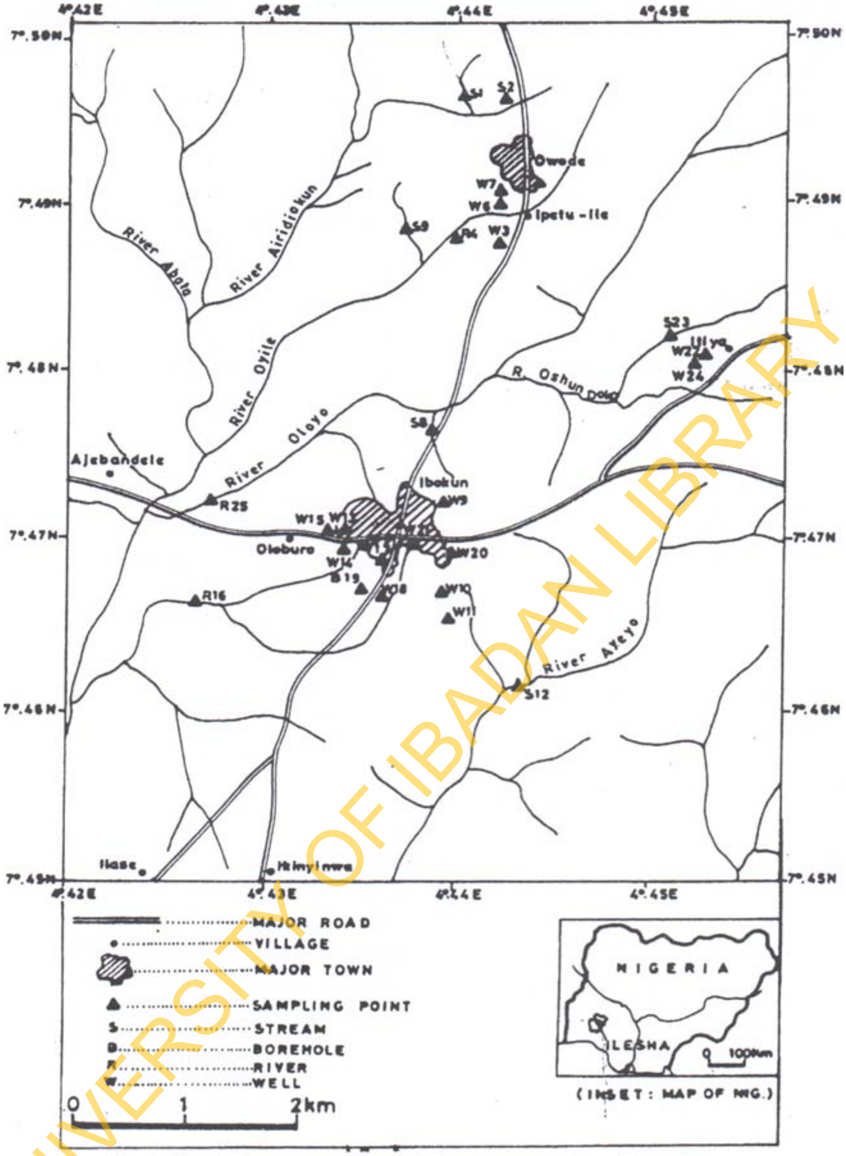

Fig. 2. Map of Ibokun area showing drainage pattern and sampling points

gniess and amphibolite. The granite gneiss with a northerly foliaiton trend, occurs in the central part of the area, seemingly as a narrow band within the amphibolite. In the northern part of Ibokun, the gneiss contains abundant, large lensoid microcline and quartz with alternating, discontinuous streak-like layers of biotite. Banding is better developed in outcrops encountered farther south, as the alternating biotite-rich layers are more persistent and distinct. Well-foliated varieties containing a high percentage of biotite and hornblende occur in the extreme south. The amphibolite include massive, banded and schistose textural types. The massive to weakly foliated types generally are dark green, relatively coarse-grained, consisting of varying amounts of bluish-green to yellowish-green, platy to sheaf-like aggregates of hornblende, set in a fine grained matrix of tabular plagioclase of labradorite-bytownite composition. Quartz, epidote and actinolite commonly occur as poikiloblastic inclusions within hornblende and plagioclase. Within the transition zones with the gneiss, banded samples occur. They are characterized by a conspicuous development of irregular to alternating bands of feldspars and amphiboles, usually up to 5cm wide. The feldpathic bands consist dominantly of plagioclase, minor quartz and occasional microline porphyroblast.

Methods of study

Twenty-five water samples were collected which comprise 15 handdug wells, 1 borehole, 6 streams and 3 rivers. These constitute the major sources of water supply for the inhabitants. Soil samples were observed visually for colour, texture and presence of fines while rocks samples were obtained for petrography observation of the mineralogy.

The top film of the surface water and groundwater were removed. About 2 litres of water sample was collected from handbug wells, borehole and surface water bodies into clean plastic containers. The samples were adequately labelled and preserved in the refrigerator until they were taken to the laboratory for chemical analysis.

The conductivity, total dissolved solid (TDS), temperature and pH were measured in the field. The concentration of Fe^{2+}, NO^-_3, PO_4^{2-}, Mg^{2+}, K^+ were determined by atomic absorption spectrometry (AAS). Digital titration method was employed for determining SO_4^{2-}, HCO_3^-, Cl^-, total hardness, Ca^{2+} while Na^+ was determined by flame photometer. Details of analytical procedure are reported in Omidiran (2000).

Discussion of results

The data for physical and chemical parameters of both groundwater and surface water in the study area are presented in Tables 1 and 2. The summary of the various parameters, their mean values as compared to the values of WHO (1984) standards is shown in Table 3.

The pH ranges from 7.00 to 9.10; temperature varies between 24.20 to 25.20°C while electrical conductivity (Ec)

Table 1. Results of physical characteristics of surface water and groundwater in the study area

Sample No	Water Source	pH	Temp°C	EC	TH	TDS	SAR
W3	GW	7.70	24.40	116.00	2.03	69.60	0.23
W6	"	7.90	27.80	560.00	27.09	336.00	0.57
W7	"	8.20	27.20	475.00	29.47	285.00	0.41
W9	"	7.60	27.50	923.00	1.32	23.40	0.91
W10	"	7.45	28.10	131.00	1.21	78.60	0.68
W11	"	7.40	26.40	540.00	1.57	32.24	0.25
W13	"	7.60	27.40	313.00	17.13	187.80	0.15
W14	"	7.80	27.30	326.00	19.72	225.60	0.86
W15	"	7.40	28.00	138.00	2.68	82.80	1.74
W17	"	8.20	28.20	503.00	31.11	301.80	0.43
W18	"	7.80	27.00	178.00	6.56	101.80	0.81
BIH19	"	9.90	27.20	149.00	2.51	89.40	0.47
W20	"	7.60	27.40	448.00	2.98	268.80	0.82
W21	"	7.80	28.00	1272.00	3.64	763.20	0.71
W22	"	8.20	26.50	113.40	65.36	680.00	0.35
W24	"	8.05	26.10	816.00	43.92	489.60	0.42
S1	SW	8.35	25.20	173.00	2.96	10.38	0.75
S2	"	8.10	24.20	172.00	3.15	10.32	0.61
S5	"	7.60	24.20	194.00	5.47	116.40	0.49
S8	"	7.80	24.80	65.00	4.36	10.32	0.61
S12	"	7.10	24.20	145.00	10.10	87.00	0.88
S23	"	7.60	24.80	6.00	2.24	36.00	0.62
R4	"	7.70	25.70	52.00	2.51	31.20	0.41
R16	"	7.45	24.50	72.00	1.69	43.20	0.69
R25	"	7.60	27.00	75.00	2.10	45.00	0.57

TH = Total hardness, mg/l $CaCO_3$; TDS=Total dissolved solids, mg/l
EC = electrical conductivity, μ-s/cm; SAR= sodium absorption ratio; GW= groundwater
SW = surface water

Table 2. Results of chemical characteristics of surface water and ground water in the study area

Sample No	Water	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Fe^{+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-	PO_4^{2-}
W3	GW	3.00	2.74	7.60	6.80	0.01	12.20	2.84	0.84	3.60	0.01
W6	"	67.00	9.72	19.00	30.00	0.01	3.05	49.70	0.01	5.00	0.01
W7	"	79.00	4.46	1.40	30.00	0.20	8.54	28.40	0.87	3.50	0.01
W9	"	1.00	2.74	7.80	4.60	0.10	18.30	17.75	1.11	4.30	ND
W10	"	ND	3.45	5.90	9.00	0.10	12.20	14.20	1.11	2.40	ND
W11	"	1.00	3.45	3.00	7.30	0.10	12.20	14.20	1.21	2.50	ND
W13	"	42.00	6.50	9.10	23.00	0.40	36.00	24.85	2.03	4.20	ND
W14	"	49.00	6.84	13.00	19.00	0.40	36.00	28.40	2.27	3.50	ND
W15	"	4.00	3.60	10.00	3.80	0.20	12.20	24.85	5.93	1.00	ND
W17	"	79.00	9.09	15.00	30.00	0.25	79.30	39.09	0.77	4.60	ND
W18	"	17.00	1.57	13.00	9.00	0.20	18.30	24.85	1.06	5.20	ND
BIH19	"	5.00	2.12	5.00	5.70	0.10	24.40	14.20	1.24	3.50	ND
W20	"	78.00	6.50	12.00	24.00	0.10	54.90	31.95	1.04	2.50	ND
W21	"	80.00	2.30	28.00	65.00	0.60	97.60	60.35	1.04	2.40	ND
W22	"	130.00	5.51	18.00	2.00	0.10	67.10	46.15	1.04	6.20	0.10
W24	"	97.00	2.74	18.00	36.00	0.05	18.30	56.80	0.86	6.50	0.01
S1	SW	5.00	3.37	7.90	7.30	0.00	12.20	21.30	1.41	7.46	0.03
S2	"	4.00	4.93	8.90	7.50	0.05	47.70	17.75	1.26	6.95	0.03
S5	"	6.00	9.48	9.40	12.00	0.60	47.70	21.30	0.09	5.39	0.01
S8	"	5.00	7.60	8.70	10.20	0.10	48.60	15.53	1.58	5.67	ND
S12	"	2.00	2.70	8.00	5.50	0.05	18.30	25.85	0.59	6.65	ND
S23	"	5.00	1.33	6.10	5.30	0.10	12.20	14.20	1.31	6.92	ND
R4	"	6.00	1.10	5.60	2.90	0.05	12.20	17.75	0.84	6.53	0.03
R16	"	2.00	2.90	6.50	8.20	0.10	18.30	14.20	4.47	6.49	0.01
R25	"	4.50	2.30	6.00	5.60	0.20	15.15	15.30	2.35	5.40	0.02

All parameter in mg/l; GW= Surface water ; ND= Not detected

Table 3. Summary of physical and chemical characteristics and WHO (1984) standards for drinking water

Measured parameter	Range	GW*	SW*	Overall mean	Acceptable level	Max permissible level [a]
Temp °C)	24.20-28.20	27.17	24.96	26.37		
pH (pH unit)	7.10-9.10	7.91	7.70	7.83	6.6	8.5
Ec (ms/cm)	6.00-1272	437.59	106.00	318.22	-	1400.00
TH (mg/l)	1.21-65.36	16.14	3.84	11.71	-	
TDS (mg/l)	10.32-763.20	250.98	46.50	177.40		1000.0
SAR (mg/l)	0.15-3.89	0.56	0.99	0.77		
Ca^{2+} (mg/l)	1.00-130	45.75	4.39	30.86	75.0	200.00
Mg^{2+} (mg/l)	1.10-9.72	4.58	3.97	4.36		
Na^{+} (mg/l)	1.40-28.00	11.61	7.46	10.11		200.00
K^{+} (mg/l)	2.0-65.0	19.08	7.17	14.79		
Fe^{+} (mg/l)	0.05-0.60	0.19	0.14	0.17	0.3	1.0
HCO^{3-} (mg/l)	3.05-97.6	31.71	25.82	29.59		
Cl^- (mg/l)	2.84-60.35	29.91	18.13	26.67		250.0
SO_4^{2-} (mg/l)	0.01-5.93	1.40	1.64	1.49	200.00	400.00
PO_4^{2-}(mg/l)	0.01-0.03	0.01	0.01	0.01		
NO_3^-(mg/l)	1.00-7.46	3.81	6.39	4.74		10.00

GW* = groundwater, SW*= surfacewater (mean concentration) for each group
a = after WHO (1984) standards

values from 6.00 to 1272 mμ/cm were also recorded (Table 1). Total hardness (total hardness as $CaCO_3$) is from 1.21 to 65.35 mg/1 while sodium absorption ratio (SAR) and total dissolved solids (TDS) range respectively 0.15 to 3.89 and 10.32 to 763.20mg/1 (Table 1).

The ranges of the chemical parameters in mg/1 are as follows: Ca^{2+} (1.00 – 130), Mg^{2+} (1.10 – 9.72); Na^+ (1.40 – 28.0), K^+ (2.0 – 65.00) and Fe^{2+} (0.05 – 0.60). Others are HCO^-_3 (3.05 – 97.6), Cl^- (2.84 – 60.35), SO_4^{2-} (0.01 – 5.93), NO_3^{2-} (1.00 – 7.46) and PO_4^{2-} (0.01 0.03) (Table 2). The mean concentration of the cations therefore is in the order $Ca^{2+} > K^+ > Na^+ > Mg^{2+} > Fe^{2+}$ while for the anions, it is: $HCO^-_3 > Cl^- > NO_3 > SO_4^{2-} > PO_4^{2-}$ (Table 2).

Statistical correlation using product moment coefficient of correlation indicates positive correlation between some pairs of parameters (Table 4). There are relatively strong correlations between TH and TDS (r = 0.70), Na^+ and K^+ (r = 0.69), TDS and EC (r = 0.60). Weaker correlations were obtained between Ca^{2+} and HCO^-_3 (r = 0.51), Ca^{2+} and Mg^{2+} (r = 0.36). Very weak correlations were observed between pH and TH (r = 0.22) and pH and Cl^- (r = 0.10).

Table 4. Correlations between some of the Hydro chemical parameters

Variable	Correlation coefficient
TH and TDS	0.70
Na and K	0.69
TDS and Ec	0.60
Ca and HCO^-_3	0.51
Ca amd Mg	0.36
pH and TH	0.22
pH and Cl	0.10

A plot of the TDS against the Na/(Na + Ca) ratio (Fig. 3), indicate that the waters may have modified their chemistry from the weathered materials derived from the underlying rocks. The majority of the samples plot in the centre of Gibbs' (1970) diagram, which points to weathering as the main pollutant. Calcium is both abundant in the earths' crust and extremely mobile in the hydrosphere; equally too, it is one of the msot common ions in subsurface water (Davis and Dewiest, 1966). In this study, Ca^{2+} has the highest cation value of 30.86mg/1 and may either be attributed to its abundance in the earth crust or are released as weathering product of feldspars, amphibole and pyroxenes. The source of HCO^-_3 with mean concentration of 29.59mg/1 in the sample can be attributed to CO_2 charge recharge (Tijani, 1994). In general, the warm temperature (up to 28.20°C mean) may also cause marked dissociation of the percolating water, leading to a build up of H^+ that is responsible for cation exchange reaction. The equally high Cl^- concentration of 25.67mg/1 suggests that the chemical characteristics of the water are influenced by recharge from meteoric water, weathering and subsequent release of ions from the underlying basement rocks. These views have been expressed by Olayinka et al. (1999) and is consistent with this study.

Concentration of Na^+, K^+ may reflect geochemical

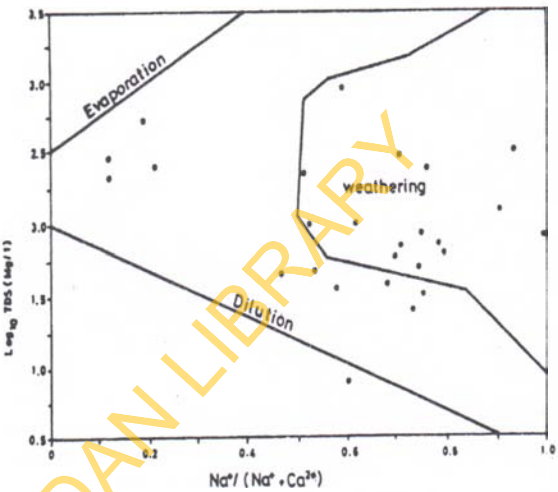

Fig. 3. Plot of TDS against the Na/(Na + Ca) ratio (after Gibbs 1970)

interactions of transported foreign material with those occurring in the area. Mg^{2+} may be associated with amphiboles, olivine, pyroxene or even clay minerals from the basement rocks. This corroborates the work of Elueze et al. (2001).

The total hardness (TH), TDS, Ca^{2+}, HCO_3, EC, pH, and temperature are higher in the groundwater than surface water. In particular, the relatively higher Ec with a range of 113.40 – 1272.00 mg/1 in the groundwater compared to a range of 6.00 – 194.00mg/1 in the surface water may be due to incorporation of dissolved components of the overburden and anthropogenic influences arising from contamination. Equally, higher average value of 6.39mg/1 for NO^-_3 in surface water compared to relatively lower average value of 3.81 mg/l in groundwater may be due to agricultural practices and direct sewage disposal into the rivers and streams (Tredoux et al., 2000).

Water types

Plots of the hydrochemical parameters of both groundwater and surface water on Piper (1944) trilinear diagram (Fig. 4), based on Furtak and Langguth (1967) classification, shows that 52% of the water is earth alkaline type with high alkaline proportion. About 44% of the water falls within the alkaline water field, while 4% belongs to the normal earth alkaline water. This characterization has revealed 4 important water facies.

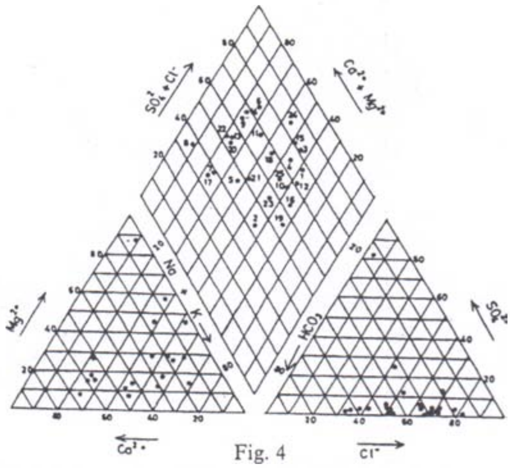

Fig. 4

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

(i) Ca – (Mg) – Na – HCO_3
(ii) Ca – Na – Cl – (SO_4) – HCO
(iii) Ca – (Mg) – HCO_3
(iv) Na – (K) – Cl – SO_4

Ca – (Mg) – Na HCO_3

This water type constitutes about 12% in the study area. Here, the water has appreciable amount of $NaHCO_3$, which is an indication of cation exchange water (Lohnert, 1973). One of the characteristics of this water type is the higher carbonate hardness as compared to the total hardness. This in effect means that there is more HCO_3^- than the available alkaline earth metal ions (Ca^{2+} and Mg^{2+}) in equivalent concentration (Lohnert, 1970). These excess bicarbonate ions then release the alkaline (notably Na^+) into the solution by exchange reaction with the cation exchangers such as clay minerals and other selected minerals that form part of the aquifer materials thus enriching the water with $NaHCO_3$.

Ca – Na – Cl – (SO4) – HCO_3

This constitutes about 40% of the water type. So_4^{2-} is a major constituent of atmospheric precipitation (Davies and Deweist, 1966). The chemistry of this water type is therefore influenced by precipitation.

Ca – (Mg) – HCO_3

This water type constitute about 4% and falls within the normal alkaline group. According to Amadi (1987), this water type is typical of Nigerian basement complex terrain with limited mixing, perhaps reflecting a primary stage of evolution of its groundwater system. Tijani (1994), reported such chemical composition to be due to the dissolution of silicate minerals in the bedrock and aluminosilicates in the weathered regolith. Arising from the geology of the area, a similar deduction may be associated with this water type.

Na – (K) – Cl – SO_4

This water type constitutes about 40% in the study area. It is also referred to as alkaline water and may likely be sourced from superficial deposits or soil cover rich in Na^+ and K^+ (Tijani and Ayodeji, 2001).

Water quality and usability

The chemical character of any water determines its quality and utilization. The quality is a function of the physical, chemical and biological parameters and could be subjective since it depends on a particular intended use (Tijani, 1994). Hence, there are different water quality standards for the various uses (Who, 1984). Drinking water standards are generally based on two main criteria. These include the presence of objectionable taste, odour and colour plus the availability of substances with adverse phyiological (health) effects.

The physical parameters such as pH, EC, TDS are within the acceptable limit of the WHO (1984) standard (Table 3). Equally, the chemical characteristics such as Ca^{2+}, Mg^{2+}, Na^+, Fe^{2+}, Cl^-, SO_4^{2-} and NO_3^{2-} have concentrations within the acceptable limit of the WHO (1984) standard (Table 3). Arising from the work of Caroll (1962), both water sources in the study area are classified as fresh based on the proportion of TDS which fall between 0 – 1000mg/l.

According to Mandel and Shiftan (1981), water containing SAR of 0 to 10 can be applicable on all agricultural soils while, that having SAR range from 18 to 26 may produce harmful effects and calls for good soil management. Sodium absorption ratio range of 26 – 100 is unsuitable for irrigational purposes. Based on the above, the hardness (TH) and sodium absorption ratio (SAR) (Richard, 1954, Sawyer and McCarthy, 1967) shows that the water is soft, and has low sodium content.

On the other hand, irrigation water criteria are dependent on water conductivity (EC), sodium absorption ratio (SAR), type of plants, and amounts of irrigation water used, soil and climate. Using Wilcox model (Table 5), the surface water is excellent, with low saline content, while the groundwater belongs to good – excellent class. However, three samples of the groundwater; W9, W21, and W24 (Table 1), could be regarded as falling within permissible irrigation water with low saline content based on this model (Table 5).

Table 5. Modified Wilcox quality classification of irrigation water[a]

Water class	Elect. Cond (ms/cm)	Salinit hazard	SAR
Excellent	<250	Low	0-10
Good	250-750	Medium	10-18
Permissible	750-2000	High	18-26
Doubtful	2000-3000	Very high	26-30

a. Source: Todd (1980)

Two principal effects of sodium are a reduction in soil permeability and a hardening of the soil. In this study, such effects are ruled out because of low SAR. Hence, it can be used to irrigate most plants (crops) and on most soils (Hem, 1985, Leeden et al., 1990). Based on the work of Leeden et al. (1990), the ranges of additional parameters such as SAR, TH, etc. are consistent with domestic supplies, recreation, wildlife propagation, irrigation and most industrial requirements.

Conclusions

Results of hydrochemical studies of both surface water and groundwater in the area show that the water is neutral to slightly alkaline with the following water facies; Ca – (Mg) – Na HCO_3, Ca – Na – Cl – (SO_4) – HCO_3, Ca – (Mg) HCO_3 and Na – (K) – Cl – SO_4.

These may reflect contribution of diversity of bedrock types and consequently also, the product of weathering. Computed values of water hardness and sodium absorption ratio indicate that the water is generally soft with low sodium content. Though most of the hydrochemical parameters show relatively higher values in the groundwater than the surface water, both satisfy the WHO standard for domestic, agricultural and other industrial uses.

It may be recommended that both water sources be developed to supplement the existing ones. Further studies should include microbial investigation, heavy metal and isotopic compositions, so as to ascertain other quality parameters and hence prescription of necessary treatment measures.

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