

HYDROGEOCHEMICAL ASSESSMENT OF GROUNDWATER QUALITY IN ADO-EKITI METROPOLIS, SOUTH-WESTERN, NIGERIA

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ABSTRACT

A total of thirty-six (36) water samples were collected randomly from thirty-six boreholes within Ado-Ekiti metropolis. Physical parameters such as pH, temperature, total dissolved solids (TDS) and electrical conductivity (EC) of the sampled borehole water were measured in-situ. The samples were analysed for their major cations, anions and heavy metals concentrations using AAS in the Central Research Laboratory, Afe Babalola University, Ado-Ekiti while the anions were analysed using titration method in the National Geo-Hazard Research Laboratory, Ibadan. The results of the cation in mg/l showed that; Na ranged from 3.80 to 122, Ca ranged from 4.20 to 270, K ranged from 6.06 to 156.70, Fe ranged from 0.02 to 1.09, Mg ranged from 0.79 to 10.20, Pb ranged from 0.00 to 0.70 and Zn ranged from 0.00 to 0.16 while the results of the anions (mg/l) showed that; HCO_3^- ranged from 0.00 to 52.00, NO_3^- ranged from 0.22 to 2.25, Cl^- ranged from 0.31 to 18.10 and SO_4^{2-} ranged from 0.19 to 1.06 and the results for the heavy metals (mg/l) showed that Cd ranged from 0.00 to 0.09, Cu ranged from 0.00 to 0.02 and Cr ranged from 0.00 to 0.009. Comparing the results with the World Health Organization Standards revealed that the all the anions analysed in the groundwater were within the WHO permissible standards, similarly, the major cations with the exception of calcium were also within the standards but this does not go down well with potentially toxic metals such as Pb, Zn, Cd and Ni which were significantly higher than the WHO recommended values. The dominance of Ca, Na and K could be attributed to weathering and leaching of silicate minerals from the underlying bedrocks, cation exchange and dissolution processes. Hence, the groundwater in Ado-Ekiti metropolis cannot be regarded as safe for drinking and other domestic purposes due to the presence of potentially toxic metals.

KEYWORDS: Hydrogeochemical, Assessment, Ado-Ekiti, Physical Parameters, Groundwater quality

INTRODUCTION

Water is the most abundant substance on the earth surface. Its unique properties make it the most important and abundant substance in the universe. Groundwater accounts for about 98% of the world fresh water and is distributed throughout the world (Tijani, 2016). Accessing quality groundwater has been a major concern for both the rich and the poor most especially in Nigeria as almost 75% of the entire population depend solemnly on groundwater for consumption.

The quality of groundwater is of vital importance, whether for industrial or domestic purposes. The quality of groundwater for different purpose depend largely on its physical, chemical and

bacteriological compositions and as a result of this various concerned agencies have set out permissible standards for water usage. According to Davis *et al*, (1966), these standards are based on two main criteria, namely; the presence of objectionable tastes, odor and color and; the presence of substances with adverse physiological effects. However, mineral enrichment from underlying rocks can change the chemistry of the groundwater, making it unsuitable for the consumption (Ako et al 1990).

Most rural areas in Nigeria depend solemnly on rivers, streams and hand-dug wells for water supply while the urban settlements depend on treated pipe-borne water and boreholes for their water supply.

In large areas of the Basement Complex, the principal source of groundwater is well. These wells have a depth of approximately 16 to 32 meters. Even though the waste products are disposed by septic tanks and the minimum distance required between the septic tanks and the wells should be about 30m (Olorunfemi and Fasuyi, 1993), this is not so well with some borehole in the study area where some are within the range of 5-20 m.

The quality of ground water depends on various chemical constituents and their concentration, which are mostly derived from the geological data. Industrial and municipal solid wastes have emerged as one of the leading cause of pollution of surface and ground water. In many parts of the country available water is rendered non-potable because of the presence of heavy metals. The situation gets tensed during dry season due to water scarcity and rain water seizure. Contamination of water resources available for domestic and drinking purposes with heavy metals and harmful microorganisms constitutes a major health concern. Recent researchers have identified high rate of exploration than its recharge, inappropriate dumping of solid and liquid wastes, lack of strict enforcement of law and loose governance as the causes of deterioration of ground water quality (Tijani, 2016; Abimbola, et al., 2002; Adeyemi, et al., 2003).

This study was carried out within Ado-Ekiti metropolis and is defined by latitudes 07°36'N to 7°39'N and longitudes 005°12'E to 005°17'E (82km²). Ado-Ekiti aside from being a capital city, it is also one of the well-populated areas in southwestern Nigeria. As of 2006, the

population was about 308,621 (FRN, 2007). The study was carried out to assess the hydro-geochemical characteristics and physicochemical parameters of groundwater in Ado-Ekiti metropolis and as well derived data that can be used for environmental monitoring of the metropolis.

Geomorphological Characteristic of the study area

The climate is of the lowland tropical rain forest type with distinct wet and dry seasons. The dry season comes up between November and April while the wet season prevails between May and October with temperature ranges between 21°C and 28 °C. The relief of Ado-Ekiti is relatively low with hills and dome shaped inselbergs. At the base of these rocks are boulders littering all over the place. The major river draining the area is Ireje and Elemi Rivers which flow south-westerly and they are associated with simple form of minor tributaries. Ireje and Elemi Rivers are seasonal with characteristic reduction in volume or total dry up in case of extreme drought (Ademilua, 1997). Ado-Ekiti has a planimetric area of about 84km² (Ademilua, 1997). It has rugged and undulating of granitic and migmatitic outcrops in several places with elevation ranging from 362 m to 445 m.

The area is well drained by rivers and streams that flow in the same direction as the rock strike. These streams take their source from high elevation and flow downhill along the strike into valleys. The drainage pattern is dendritic with irregular branching of tributary streams. This pattern

of drainage is controlled by the geology of the area, where most of the streams flow in the south-western direction. Most of the

older rivers show meandering of some streams which result from the structural pattern of the present rocks (Figure 1).

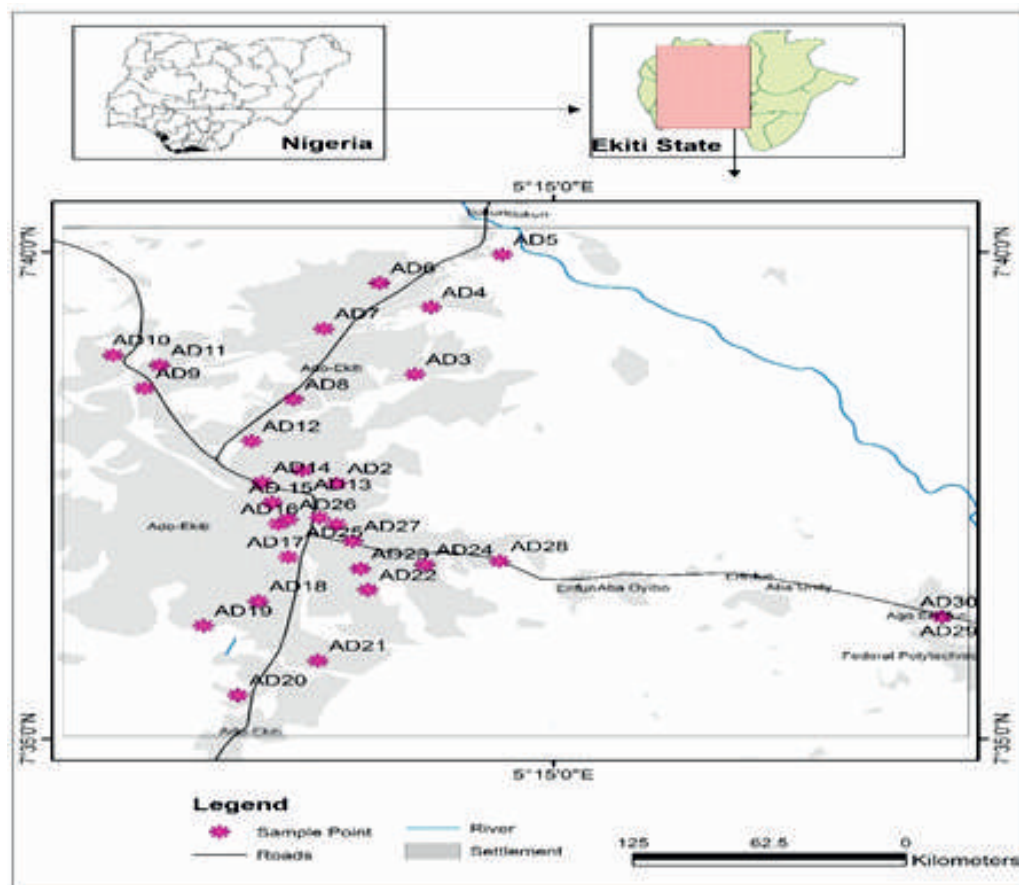


Figure 1. Location map of Ado-Ekiti metropolis (the study area)

Geology of the study area

Ado-Ekiti is one of the millennium cities in Southwestern Nigeria and it is located at the eastern part of the Basement Complex of South Western Nigeria. The Basement Complex of Nigeria consists of predominantly Archaean polycyclic gray gneisses of granodioritic to tonalitic in composition; remnants of unconformable Proterozoic cover now represented by variably migmatized metasediments which are preserved in synclinal schist belts; and many syntectonic to late tectonic intrusions (Ajibade *et al.*, 1987). The

Proterozoic sediments have been classified into the older metasediments of Early Proterozoic age and the Younger metasediments of the Pan African age (Dada, 1989). Reactivated Archaean basement often referred to as the migmatite-gneiss complex, occupies nearly half of the surface area of Nigeria. It includes the migmatite-gneisses of the zinder in-lier in Niger-Republic in the northeast; those of Obudu and Obanmassif (Ekwueme *et al.*, 1989) in southeast Nigeria; the migmatite-gneiss complex in neighboring Cameroon Republic. The

migmatite-gneiss complex is dominated by quartzo-feldspathic-biotite-hornblende bearing gneiss, schist and migmatite in which minerals such as garnet, silimanite, kyanite and staurolite suggest high-amphibolite facies metamorphism (Oyawoye, 1972). Rahman (1976) divided the Basement Complex of Nigeria into the Migmatite – Gneiss Complex, the Schists belts and the Older Granites and Related rocks

Major lithological rock units in Ado-Ekiti are crystalline basement rocks. These include coarse grained charnockites, fine-grained granite, medium-grained granite and porphyritic biotite-hornblende granite with superficial deposits of clay and quartzite. Association of the fine-grained charnockites and the porphyritic biotite-hornblende granite suggest a common age (Olaewaju, 2006).

Hydrogeological Setting of the Basement Complex

Basement Complex rocks are poor aquifers as they are characterized by low porosity and negligible permeability, resulting from their crystalline nature. Appreciable porosity and permeability may be developed through weathering and fracturing, depending on the lithology and texture of the parent rock. The availability of groundwater would depend on the presence and extent of the weathered overburden and regolith and the presence of faults and fractures in the underlying bedrock (Olayinka et al., 1999).

The Regolith includes both the residual soil and the saprolite. The latter is derived from in-situ weathering and has become largely disaggregated. The

residual soil usually developed from the underlying saprolite unit by further dissolution and leaching combined with other chemical, physical, and biological processes (Olorunfemi and Fasuyi, 1993). Over very long periods, infiltrating carbonic acid-charged rainfall will react with alkaline minerals, leaching the more soluble and mobile components and precipitating less mobile minerals with the formation of kaolinite and Fe-Al oxides. Such apparently leached portion of the weathered unit, which is underlain locally by laterite bed (hard part) or stone lines, are almost always in the vadose zone and thus of significance in the relation to its recharge.

Dissolution of minerals and leaching tends to increase porosity, permeability and specific yield, but the decomposition of secondary clay minerals tend to reverse this process (Tijani, 1994). Schistose metamorphic rocks, and also zones of tectonic disturbances, are likely to promote deeper weathering and a thicker regolith, although the presence of abundant Fe-Mg minerals (such as biotite), which readily weathers to secondary products, is likely to further reduce permeability. Most hand-dug wells tap their water from the weathered regolith. The bedrock included both the weathered sap rock and fresh variably fractured bedrock. The bedrock in the Basement Complex is highly fractured due to the fractured nature of this zone the groundwater yield is high compared to the weathered overburden (saprolite). The water is held within the fractures.

MATERIALS AND METHODS

The study involved both field and laboratory activities. The field activity

involved collection of water samples from different boreholes and in-situ measurement of physical parameters while the laboratory work involved chemical analyses of cations and anions. A total of thirty (36) water samples were collected randomly within Ado-Ekiti metropolis different from thirty-six bore-holes. Sample collection took place in the month of January before the onset of raining season to ensure the effluents from surface run off were mixed with the sampled water. The water samples were collected into cleaned plastic bottles which were earlier rinsed with the particular water to be sampled. Two sets of samples were collected from each site; the first sets were acidified with one or two drops of concentrated HNO_3 for cations determinations while the second set were unacidified for anions determination. In-situ tests of physical parameters were carried out at every sampled site using HANA model HI 83200 multi-parameter ion specific meter. These measurements include temperature, pH, electrical conductivities and total dissolved solids (TDS) while the hardness of the groundwater were calculated. The samples were then transported to the laboratory and refrigerated prior to further analysis. The samples were analyzed for bicarbonate, chloride, sulphate, nitrate, calcium, magnesium, sodium, potassium, iron, lead, zinc, nickel, chromium, cadmium, cobalt and manganese using standard procedures recommended by APHA, 1998. Cations analyses were carried out using Atomic Absorption Spectrometric method and Flame Spectrophotometry while anions

determination was by Calorimetric (HCO_3^{2-} and NO_3^-), Volumetric (Cl^-) and Turbidimetric (SO_4^{2-}) methods with values recorded in mg/l. The concentrations of Ca^{2+} , Na^+ , K^+ , Mg^{2+} , Fe^{2+} , Cd^{2+} , Cu^{2+} , Pb^{2+} , Zn^{2+} , Mn^{2+} , Ni^{2+} and Cr^{3+} were analysed using AAS at the central microbiological research laboratory, Department of Biological Sciences, Afe Babalola University, Ado-Ekiti. However, the concentrations of NO_3^- , SO_4^{2-} , HCO_3^{2-} and Cl^- were determined at the National Geo-Hazard Research Laboratory, University of Ibadan, Nigeria.

RESULTS AND DISCUSSION

The Data obtained from field measurement and laboratory analyses were subjected to statistical treatments using SPSS 22.0 and subsequently compared with the recommended standards. Then ultimate conclusion was drawn on the quality of the groundwater from the study area. The statistical summary of the chemical and physical analyses on the groundwater samples is presented in Table 1. The pH of the water samples in the study area ranged from 5.9 to 7.1 which indicates that the groundwater is slightly acidic to neutral water types. These values are within the permissible limits of 6.5 – 9.5 set by WHO, (2008) however, a few locations such as Ekute, Okesa, Idolofin, Odo-Ado, Housing Estate and Moferere have pH below the recommended values. pH values affect the mobility of most elements. Offodile (2002) confirmed the solubility of Na^+ , K^+ , Cl^- and NO_3^- ions within the entire range of pH in normal groundwater

Table 1. Concentration values of physico-chemical parameters

Parameters	Min	Max	Mn.	SD	WHO (2008)
Temp	27.0	31.3	29.2	0.3	27
pH	5.9	7.1	6.8	0.3	6.5-9.5
TDS	292	1907	840.6	65.1	500
EC	40	311	249.9	25.9	1200
Ca ²⁺	4.2	270	69.7	69.9	75
Mg ²⁺	0.79	10.2	7.3	2.9	50
K ⁺	6.06	156.7	44.68	38.49	10
Na ⁺	3.8	122	41.11	37.4	50
Mn ²⁺	0.01	1.0	0.15	0.22	0.3
Fe ²⁺	0.02	1.09	0.2	0.22	0.3
Pb ²⁺	0.001	0.7	0.2	0.17	0.01
Zn ²⁺	0.001	0.16	0.036	0.037	0.01
HCO ₃ ²⁻	0.001	52	9.12	12.8	100
NO ₃ ⁻	0.22	2.25	0.48	0.36	50
Cu ²⁺	0.01	0.03	0.02	0.01	0.5
Cl ⁻	0.31	18.1	7.9	5.8	250
Cd ²⁺	0.001	0.09	0.14	0.18	0.003
SO ₄ ²⁻	0.19	1.06	0.61	0.26	250
Ni ²⁺	0.001	0.11	0.04	0.03	0.02
Cr ³⁺	0.001	0.09	0.014	0.025	0.05

All units except pH, Temperature (°C) and Electrical conductivity (µS/m) are in mg/l, SD = Standard Deviation, Min. = Minimum, Max. = Maximum, Mn = Mean

Acidity in groundwater in these areas could be attributed partly to seepage and atmospheric precipitation of carbonic acid, which infiltrates into the groundwater system to reduce the pH of the groundwater, and increase acidity. Total Dissolved Solids (TDS) of the water samples ranges from 292 - 1907mg/l with an average of 840.64mg/l, these values are by far above the permissible limits of WHO (2008) set-out standard. Classification of water based on

TDS shows that the groundwater falls within the fresh and slightly saline water types. Electrical Conductivity (EC) values measured from samples in the study area range from 40 uS/cm to 311uS/cm (av. 249.99 uS/cm). The EC values from the area are within the permissible limit set by WHO (2008). The concentrations of major cations; Na⁺, Ca²⁺, K⁺ and Mg²⁺ ranged from 3.8 to 122 mg/l (av. 41.11 mg/l), 4.20 to 270 mg/l (av. 69.7 mg/l), 6.06 to 156.7 mg/l (av. 44.68 mg/l) and 0.79 to 10.20 mg/l (av. 7.13 mg/l) respectively (Fig.2b). Meanwhile, the concentrations of metallic cations like Fe²⁺, Mn²⁺, Pb²⁺, Zn²⁺, Cd²⁺, Ni²⁺, Cu²⁺ and Cr³⁺ ranged from 0.002 to 1.09 mg/l (av. 0.2 mg/l), 0.001 to 1.0 mg/l (av. 0.015 mg/l), 0.01 to 0.7 mg/l (av. 0.20 mg/l), 0.01 to 0.16 mg/l (av. 0.04), 0.01 to 0.09 mg/l (0.14), 0.001 to 0.11 mg/l (av. 0.038), 0.001 to 0.02 mg/l (av.0.003) and 0.001 to 0.09 mg/l (av. 0.014 mg/l) respectively (Figure 2c). These ranges of cations values are within the WHO (2008) standards for drinking water with the exception of Fe²⁺, Ca²⁺, K⁺ and Na⁺ (Table 1) in some locations. However, their average values are still within the permissible values of WHO standards for drinking water. The high Na, Ca, K and iron concentrations in most of the samples could be attributed to interactions between groundwater and the underlying bedrocks (cations exchange processes). Most of the water samples were clear on abstraction from the well but a few were cloudy and brownish which may be due to precipitation of these ions in the groundwater, their hydrological conditions, and complex physiochemical and biochemical factors such as pH and redox

potential (Eh), the dissolved carbon dioxide and sulphur species.

Major anions (HCO_3^{2-} , NO_3^- , SO_4^{2-} and Cl^-) concentrations range from 0.001 to 52 mg/l (av. 9.12 mg/l), 0.22 mg/l to 2.25 mg/l (av. 0.48 mg/l), 0.19 mg/l to 1.06 mg/l (av. 0.61 mg/l), 0.31 to 18.1 mg/l (av. 7.9 mg/l) respectively (Figure 2a). The concentrations range of these anions in the study area are below their respective WHO permissible standard for drinking water and therefore poses no problem for the groundwater quality. The low

concentrations of SO_4^{2-} could be probably due to the removal of SO_4^{2-} by the action of bacteria (Amadi et al., 1989). The low concentrations of sulphate suggest that there no infiltrations from septic tanks in the area. Similarly, the concentrations of Nitrate, chloride and bicarbonates are below the WHO (2008) permissible limit for drinking water at most location reveals a satisfactory in water quality in these areas (Egboka et al., 1989, Adelana and Olasehinde, 2003).

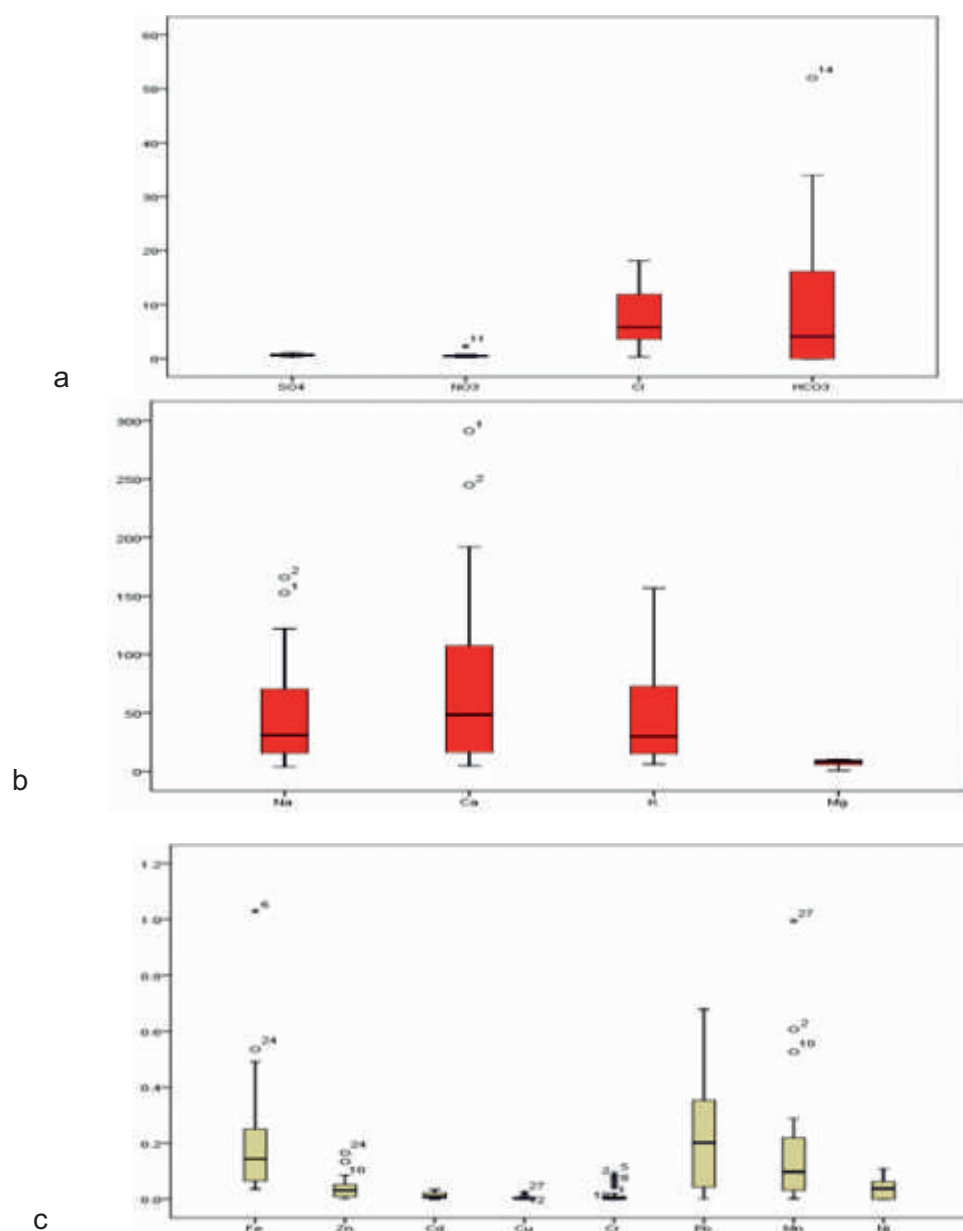


Figure 2. Box plots of analyzed a) anions, b). major cations and c). trace metals in groundwater of the study area

The average concentrations of all the major elements were compared against one another and it was observed that Calcium has the highest value in the study area followed by potassium then sodium while chromium has the least concentration. The dominance of Ca and K was as a result of the weathering of the mafic minerals in the underlying bedrocks like feldspar, mica and

other related minerals constituting in the basement rocks. Similarly, comparing the average concentrations of the analyzed parameters with the WHO standards showed that TDS, K and all the trace metals with the exception of Fe and Mn were significantly higher than the WHO permissible standards (Figure 3).

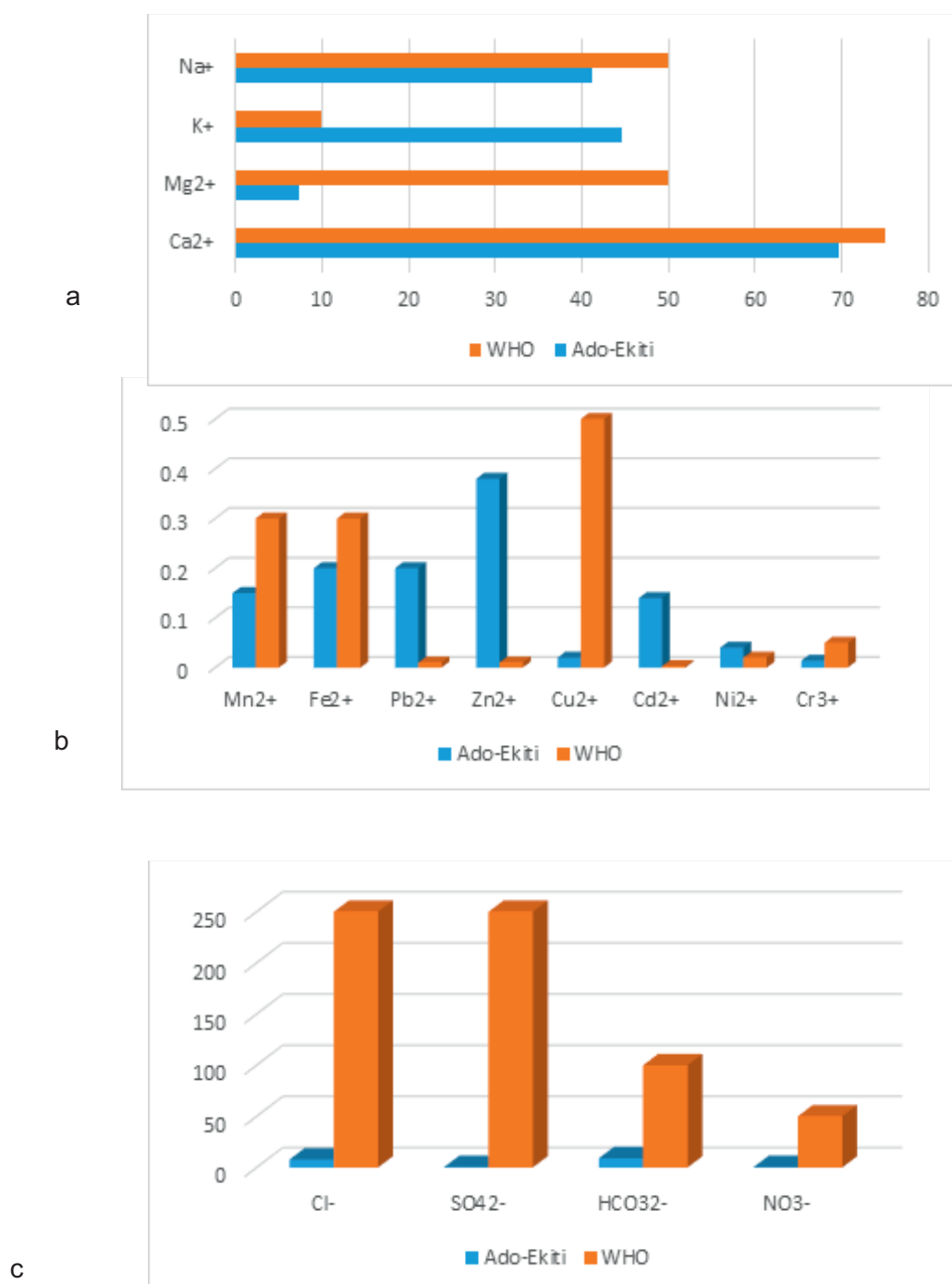


Figure 3. Comparing the average concentrations of some parameters with WHO Standards

Geochemical Associations among the Parameters

Correlation Analysis

Correlation was done to state the relationship among metals and similarities in their geochemical behavior. The analysis revealed a wide range of variation in the correlation values as both positive and negative correlations were established between some of the elements. The variability in the correlation coefficients amongst the parameters is an indication that different geochemical factors have influenced their concentrations in the groundwater samples (Table 2). The strong and positive associations that exist among Na, Ca, K, Mg, Zn, Cd and Ni showed that these metals were contributions from groundwater-bedrocks interactions while the strongly positive association among Pb, Mn, Fe, Cl, SO₄, NO₃ and HCO₃ were contributions from

anthropogenic activities that characterised the study area.

Factor Analysis

Principal component analysis (PCA) has been widely used in identify and differentiating contamination sources. This analysis has been used to find out the possible linear combination of the original variables of hydrochemical parameters which could account for the largest part of the total variance. Reduction in variables during future monitoring of the groundwater system without significant loss of information can be done by this method (Pavoni et al., 1987). The resulting geochemical data from the groundwater analysis were subjected to six principal component analysis using SPSS 22.0. The result of the PCA revealed that most of the variables were fractionated into PC 1 which accounted for about 26% of the total variable with an eigen value of 4.15 (Table 3).

Table 2. Result of correlation analysis of groundwater from the Study Area

	Na	Ca	K	Fe	Mg	Zn	Cd	Cu	Cr	Pb	Mn	Ni	SO ₄	NO ₃	Cl	HCO ₃
Na	1															
Ca	.97**	1														
K	.83**	.79**	1													
Fe	-.24	-.23	-.27	1												
Mg	.62**	.55**	.61**	-.29	1											
Zn	.69	.90	.81	.41	.83	1										
Cd	.76	.92	.97	.29	.72	.72	1									
Cu	.85	.70	.95	.67	.67	.83	.45*	1								
Cr	.23	.26	.68	-.28	.33	.60	.17	-.22	1							
Pb	-.24	-.26	-.28	.47	.51	-.52	-.17	.50	.20	1						
Mn	.42	.48	.85	.17	.60	.38	.68	.10	.99	.99	1					
Ni	.61	.61	.91	.78	.63	.81	.42	.68	.63	.61	.60	1				
SO ₄	.69**	.70**	.61**	-.32	.54**	-.29	.77	.93	.17	.95	1.00	.73	1			
NO ₃	.48	.63	.48	.12	.97	.69	.59	.34	.98	.86	.23	.14	.61	1		
Cl	.07	.05	.27	.07	.97	.77	.25	.29	.69	.04	.77	.15	.31	.78	1	
HCO ₃	.60**	.52**	.64**	-.31	.49**	-.28	.61	.58	.85	.95	.50	.60	.63**	-.17	.72	1

** . Correlation is significant at the 0.01 level (2-tailed). * . Correlation is significant at the 0.05 level (2-tailed).

This PCA is strongly and positively loaded with Na, Ca, K, Mg, SO_4^{2-} and HCO_3^- which is an indication of common/similar source especially with respect to dissolution of bedrocks by carbonate (CO_3^{2-}) charged rainwater. PCA-2 comprises of Na, Fe, Cd, Cr and Cl which can be attributed to the anthropogenic factor while PCA-3, 4 and 5 are contributions from anthropogenic activities as a result of leaching and percolation from overburden materials (Table 3. and Figure. 4).

Groundwater Facies Classification

The hydrochemical evolution of groundwater can be understood by plotting the major cations and anions in a piper trilinear diagram (Piper, 1944). This diagram reveals similarities and difference among groundwater samples because those with similar qualities will tend to plot together as groups. The piper trilinear diagram below (Figure 5) is a plot of the major cations and anions of groundwater samples from the study area.

Table 3. Factor Analysis Data interpretation

	1	2	3	4	5	6	Communalities
Na	.93	0.58	0.10	-0.23	0.08	0.10	0.83
Ca	.90	-0.08	-0.24	0.16	-0.11	0.19	0.85
K	.86	0.19	-0.25	0.00	-0.07	0.04	0.89
Fe	-0.41	0.65	-0.11	0.11	0.26	0.22	0.74
Mg	0.72	-0.02	0.05	0.42	0.13	0.10	0.79
Zn	-0.23	-0.14	-0.61	0.24	-0.07	0.12	0.86
Cd	0.03	-0.57	0.29	0.04	0.40	-0.24	0.71
Cu	0.11	-0.16	-0.20	-0.49	0.74	-0.26	0.93
Cr	0.17	-0.56	0.53	0.50	0.04	0.17	0.90
Pb	-0.13	0.17	0.72	-0.02	0.32	0.26	0.74
Mn	0.00	-0.12	-0.46	0.14	0.64	0.40	0.83
Ni	-0.07	0.34	-0.05	0.44	0.10	-0.72	0.85
SO_4	0.82	0.03	0.13	0.11	0.09	-0.08	0.76
NO_3	-0.21	0.17	-0.26	0.60	0.23	-0.12	0.76
Cl	-0.31	0.62	0.38	0.22	0.12	0.09	0.79
HCO_3	0.80	0.21	0.13	-0.11	0.07	-0.20	0.76
Eugen Value	4.15	2.09	1.90	1.46	1.41	1.1	-
% Variance	29.80	13.06	11.87	9.14	8.83	7.84	-
Cum.%	29.80	42.86	52.34	61.70	70.06	77.96	-

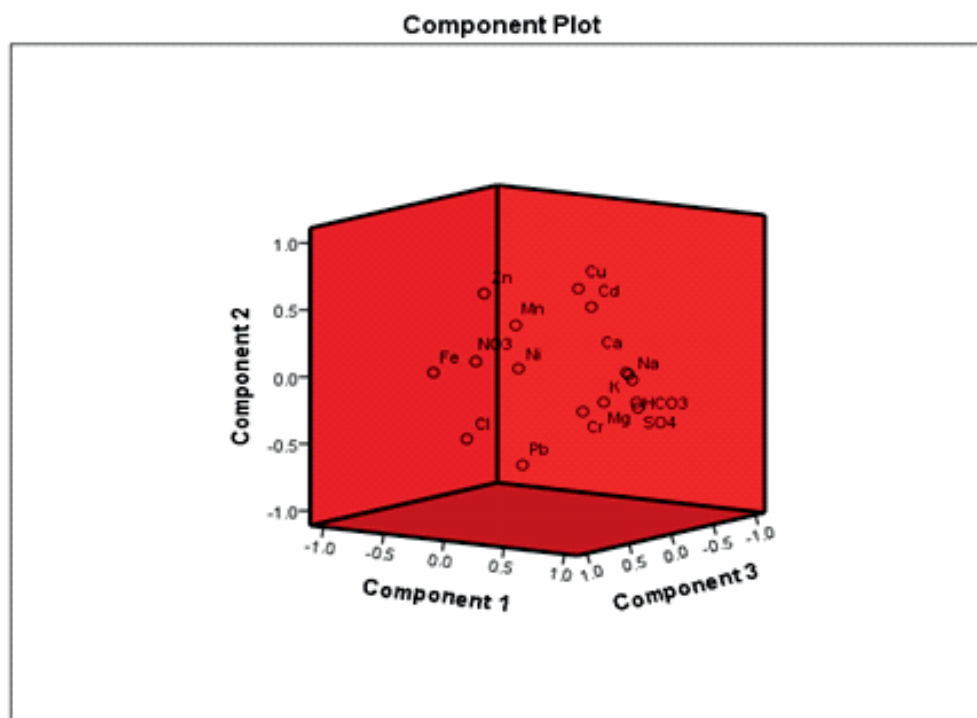


Figure 4. Graphical Interpretation of the Factor Analysis

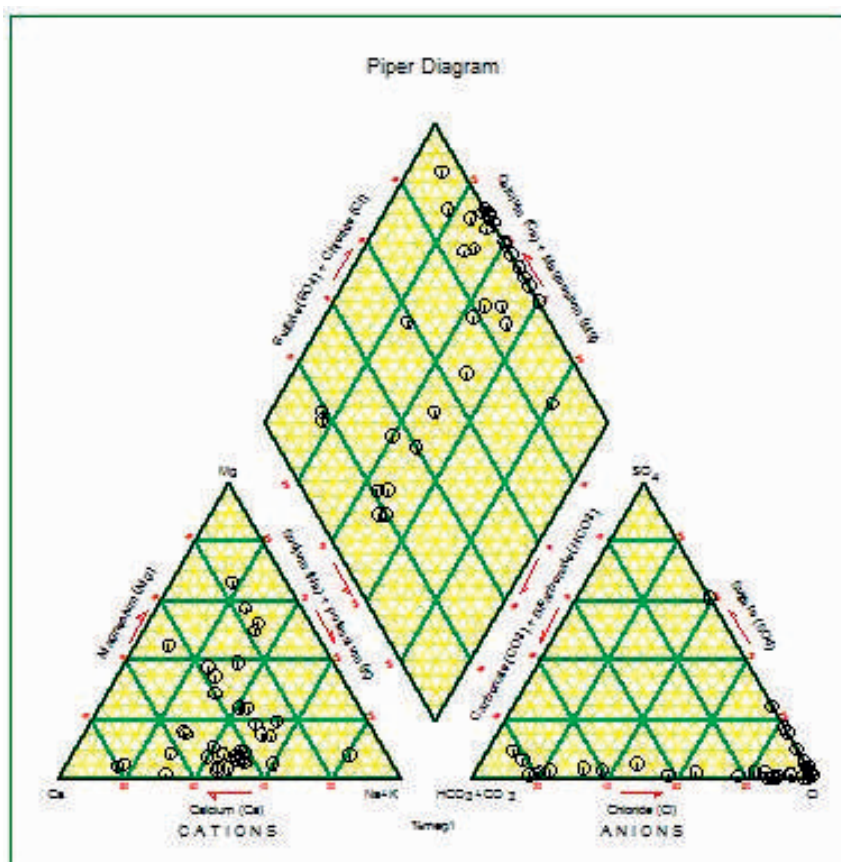


Figure 5. Piper plot of major cations and anions

To know the hydrogeochemical regime of the study area, major cations and anions such as Ca^{2+} , Mg^{2+} , Na^+ , K^+ , HCO_3^- , SO_4^{2-} and Cl^- in mg/l were plotted in Piper (1994) trilinear diagram as the percent of the major constituents (Fig. 5). On the piper diagram, the relative concentration of the cations and anions were plotted in the lower triangles, and the resulting two points are extended into the central field to represent the total ion concentration. The groundwater facies revealed in this study are the dominant Ca-(Na)-Cl- HCO_3^- as fresh water type and minor occurrence of Na-(K)-Cl- as brackish water type. The observed facies is a reflection of the wide range and high standard deviation observed in the ionic concentration of Na^+ and Cl^- in the dataset.

CONCLUSION

This work assessed the physical and chemical parameters of groundwater in some bore-holes within Ado-Ekiti metropolis South-western, Nigeria. The pH values of the water samples from the study area fell within the range of moderately acidic to neutral. Based on the Health (1987) classification, almost all the water from the study area can be regarded as fresh to slightly saline water. Comparing the results with the World Health Organization Standards revealed that all the anions analysed in the groundwater were within the WHO permissible standards, similarly, the major cations with the exception of calcium were also within the standards but this does not go down well with potentially toxic metals such as Pb, Zn, Cd and Ni which were significantly higher than the WHO recommended values. The dominance of Ca, Na and K could be

attributed to weathering and leaching of silicate minerals from the underlying bedrocks, cation exchange and dissolution processes. Hence, the groundwater in Ado-Ekiti metropolis cannot be regarded as safe for drinking and other domestic purposes due to the presence of potentially toxic metals. For sustainable groundwater management, route hydrochemical assessment should be adopted to monitor groundwater quality of the city.

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