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THE PHYSIOCHEMICAL CHARACTERISTICS OF WATER IN HAND DUG WELLS AROUND EKITI STATE UNIVERSITY ADO-EKITI, SOUTHWEST NIGERIA

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ABSTRACT

There has been no supply of pipe borne water to Ekiti State University. Majority of students/people living around the university environment depend on water from hand dug wells for their water needs. Physical and chemical evaluation of twenty hand dug well water employing standard method was carried out with a view to characterize and ascertain their potability. The physical analysis revealed that pH ranged from 6.61—7.84 (av. 7.15) indicating almost neutral water. EC of 20 – 380 (av.89.50) µS/cm and TH of 10.86 – 121.80 (av. 36.49) mg/L $CaCO_3$ revealed soft water with low dissolved solutes. Result of the chemical analysis showed that Ca^{2+} ranged from 2.28 – 38.74 (av.9.57) mg/L, Mg^{2+} from 0.51 – 13.13 (av. 3.06) mg/L, Na^+ from 1.52 – 88.68 (av.18.18)mg/L and K^+ from 1.32 – 10.92 (av. 4.00) mg/L. Similarly, concentrations of HCO_3^- ranged from 15.25 – 61 (av. 36.60) mg/L, SO_4^{2-} from 4.60 – 19.60 (av. 10.70)mg/L, Cl^- between 72 and 432 (av. 160.65)mg/L and NO_3^- from 0.11 – 4.03 (1.58)mg/L. Well water samples analyzed in the study area exhibited an overall ionic dominance of $Na^+ > Ca^{2+} > K^+ > Mg^{2+}$ for the major cations on the one hand and $Cl^- > HCO_3^- > SO_4^{2-} > NO_3^-$ on the other hand. The chemical concentrations as observed in the chemical analysis indicated that all the chemical parameters are within approved WHO standard for drinking water except Cl^- that exceeded the value in few locations signifying localized anthropogenic contamination. Well water samples analyzed in the study area exhibited an overall ionic dominance of $Na^+ > Ca^{2+} > K^+ > Mg^{2+}$ for the major cations on the one hand and $Cl^- > HCO_3^- > SO_4^{2-} > NO_3^-$ on the other hand. The well water were characterized as Na-Cl water type (55%) followed by Ca-Cl (30%) and mixed Ca-Mg-Cl type (15%). The research indicated that the well water is soft, low mineralized and potable.

Keywords: Pipe borne water, Hand dug well, Potability, Dissolved solutes, Anthropogenic contamination

INTRODUCTION

Water has been used by man, plants and animals in various ways. Man uses it for drinking, household washing, agricultural purposes, industrially, auto drive and as fire combating agent. Plants use it for growth and preparation of their food during photosynthesis. Water plays a major geomorphic role in rock weathering, formation and modification of landforms. It has a unique property of being a universal solvent easily dissolving a wide range of chemical substances and facilitating the dispersal of undissolved matters. The physiochemical characteristics of water determine its usefulness for domestic, industrial, recreational and agricultural purposes.

The hand dug well water is used by those living around the university vicinity for washing, cooking, laboratory work and bathing. Each of these purposes is influenced by the quality of the water used. Man is entitled to clean and high quality water uncontaminated and unpolluted water supply for his household needs. Majority of inhabitants living in the local or urban settlements depend on rainfall water harvesting, pipe borne water supply, surface and groundwater in contrast to the university polyglots that have less accessibility to treated pipe borne water and/ or borehole water. Due to non-accessibility of this quality water, people resort to the use of hand dug well water no matter the condition and irrespective of the sanitary conditions. It is on the basis of these shortcomings that warrants assessing the physiochemical characteristics of the well water with a view to determine their suitability for domestic purposes and alert the community on the consequences of water borne diseases that may result from its consumption.

The quality of water is also influenced by the type of rock and soil, environment and catchment area, as well as the anthropogenic activities within the sighted wells. The groundwater quality is affected by the combined effects of physical, chemical and biological processes as the water moves along hydrologic pathways over, under and through the land (Meybeck and Helmer,1989, Lundqvist, 1989). The physical and chemical changes that alter the hydrologic pathways that change the water quality include the removal of soil surfaces, vegetation through road construction, farming, urbanization, land drainage as well as addition of unwanted wastes to the landscape. Natural water quality has no universal reference due to high variability in the chemical quality of the water (Meybeck, 1996). Most hand dug wells in Ado-Ekiti were studied and found to be sited close to the location of pit latrines, septic tanks and in areas where human faeces and animal dugs are openly littered here and there. Sewage and refuse dumps are often found close to areas where wells are sited and during rains they leach and infiltrate into the groundwater and follow the subsurface hydrologic water regime. Most of them contain high coliform and E-coli counts that are above the World Health Organisation (WHO) drinking water standards suggestive of contamination. (Obasi and Anyanwu, 2001, Talabi and Ogundana, 2014).

Water is a carrier of undesirable physical, chemical and bacteriological matters that constitute contaminants and to higher degrees pollutants. The sanitary certainty of water has to be regularly monitored, analysed and evaluated to check the influx of unwanted matters and to ensure the safety of the consumers. Quality drinking water is essential for life (Nkansah, 2010). Water scarcity is one important challenge that faces communities that hitherto lack pipe borne water or surface water supply. Water is an everyday commodity need of man and all efforts should be made to make it available in sufficient quantity and quality. Thus this study aimed at determining the physico-chemical characteristics of hand dug wells around Ekiti State University with a view to characterize the water and ascertain its suitability for domestic purposes.

LOCATION OF STUDY

The study area is the university community and its environ situated in Ado Ekiti. Ado Ekiti lies between longitudes 5^{o} 13′ and 5^{o} 16′E and latitudes 7^{o} 36′ and 7^{o} 49′N. The university and the surrounding residential areas are linked with roads and footpaths created by students from their various hostels (Fig. 1).

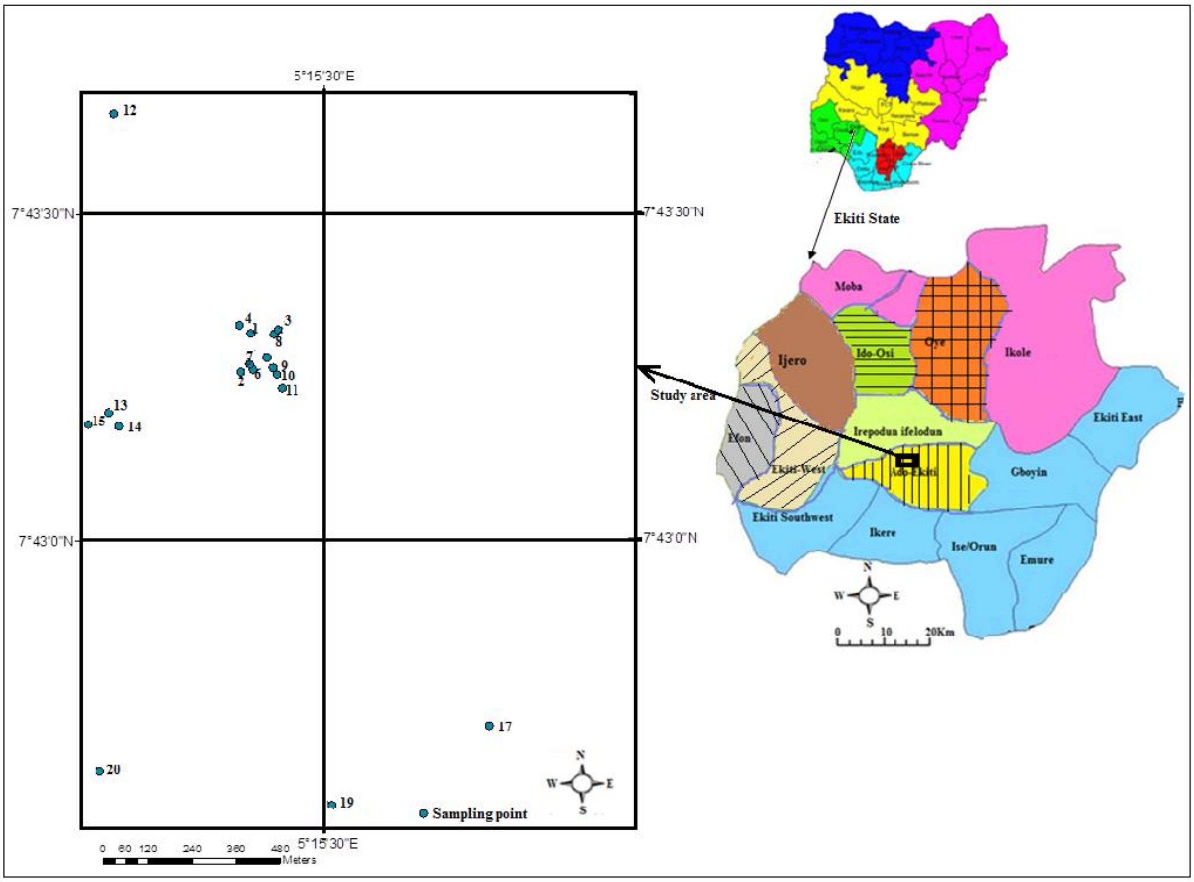

Fig. 1. Location of Study

MATERIALS AND METHODS.

Two major steps were involved in the methodology of this research (Field operations and Laboratory analysis). The field operations were conducted during the dry season in November, 2015. Wells survey was carried out to decide on wells to be sampled. Subsequently, 20 well water samples were collected into polyethylene bottles that have been thoroughly washed in two sets for cations and anions determinations respectively. Samples meant for cations analysis were acidified with concentrated Nitric acid to a pH of about 4. All samples were refrigerated at a temperature of -4°C before being transported to FatLabs Laboratory at Agbowo in Ibadan Nigeria for analysis. Prior to sampling insitu parameters (Temperature, pH and EC) were determined employing Multiple Potable Testr Meter which was calibrated prior to taking of readings. In addition at each location co-ordinates of sampling point were measured and recorded using etrex GARMIN GPS while depth of wells were measured employing Dipmeter. The site map of the sampling locations was subsequently obtained using Sulfer-8 software to plot the co-ordinates. Chemical analysis of the samples was conducted using standard procedures recommended by APHA- 1998. Total hardness was calculated using:

TH (CaCO3) mg/L = 2.497Ca + 4.115Mg (Todd, 1980) (1).

The chemical concentrations of major cations (Ca^{2+}, Mg^{2+}, and K^{+}) and anions (Cl^{-}, HCO_3^{-}, SO_4^{2-}, and NO_3^{-}) were determined using multiparameter photometer (Hanna, HI83099). Analysis of Na^{+} ion concentrations was done using a Sherwood model 420 flame photometer.

Data obtained were evaluated using Microsoft Excel. Piper and Schoeller diagrams were plotted employing GW_Chart and Microsoft Excel respectively. The results were appraised in accordance with the drinking water quality standards recommended by the World Health
Organization WHO (2004).

RESULTS AND DISCUSSION

The results of the physical and chemical parameters in this research are presented in Tables 1 and 2 respectively. The results as in Table1 revealed an average temperature of 21.35°C, pH that ranged from 6.62 – 7.84, Ec of 20.00 – 380.00µS/cm and TH in the range of 10.86 – 121.80mg/L. The values of the physical parameters are within approved WHO (2004) drinking water standard values. The low values of EC<1000µS/cm indicates fresh water (Freeze and Cherry, 1979). In addition all the well water samples have pH values within the recommended pH of 6 - 9 WHO (2004). TH values of the analysed well water are below the recommended limit of 500mg/L ($CaCO_3$) for drinking water by WHO (2004) standard value
.

Table 1: Results of Measured Physical Parameters from the Study Area

Code	Latitudes	Longitudes	Temp. °C	pH	EC (µS/cm)	TH (mg/L)	Depth (m)
EKSU 1	N7⁰ 43.3153′	E5⁰15.385 ′	21.00	6.62	70.00	19.38	19.74
EKSU 2	N7⁰ 43.3143′	E5⁰ 15.420′	19.00	6.81	40.00	40.09	23.50
EKSU 3	N7⁰ 43.3206′	E5⁰ 15.426′	22.00	6.87	160.00	61.95	43.24
EKSU 4	N7⁰ 43.3279′	E5⁰ 15.368′	23.00	6.96	40.00	10.86	29.14
EKSU 5	N7⁰ 43.2573′	E5⁰ 15.370′	23.00	7.1	40.00	31.38	29.14
EKSU 6	N7⁰ 43.2604′	E5⁰ 15.388′	23.00	6.95	30.00	12.15	33.84
EKSU 7	N7⁰ 43.2689′	E5⁰ 15.383′	20.00	7.01	60.00	25.85	23.50
EKSU 8	N7⁰ 43.2785′	E5⁰ 15.408′	25.00	7.55	20.00	19.45	23.50
EKSU 9	N7⁰ 43.2631′	E5⁰ 15.418′	25.00	7.15	130.00	100.11	22.56
EKSU 10	N7⁰ 43.2529′	E5⁰ 15.424′	21.00	7.57	40.00	12.71	31.96
EKSU 11	N7⁰ 43.2304′	E5⁰ 15.432′	21.00	7.27	70.00	15.79	24.44
EKSU 12	N7⁰ 43.6531′	E5⁰ 15.184′	22.00	6.92	180.00	44.24	21.62
EKSU 13	N7⁰ 43.195′	E5⁰ 15.174′	21.00	7.1	60.00	45.79	23.50
EKSU 14	N7⁰ 43.174′	E5⁰ 15.189′	20.00	7.09	380.00	121.80	31.96
EKSU 15	N7⁰ 43.177′	E5⁰ 15.142′	22.00	7.1	100.00	24.70	24.44
EKSU 16	N7⁰ 43.230′	E5⁰ 15.127′	22.00	7.09	130.00	25.39	2.56
EKSU 17	N7⁰ 42.7114′	E5⁰ 15.737′	18.00	6.84	60.00	26.64	20.68
EKSU 18	N7⁰ 42.7103′	E5⁰ 15.961′	20.00	7.55	110.00	58.56	18.8
EKSU 19	N7⁰ 42.5921′	E5⁰ 15.503′	20.00	7.84	50.00	20.02	27.26
EKSU 20	N7⁰ 42.6452′	E5⁰ 15.157′	19.00	7.55	40.00	12.89	31.96
		Min	18.00	6.62	20.00	10.86	2.56
		Max	25.00	7.84	380.00	121.80	43.24
		Mean	21.35	7.15	89.50	36.49	25.37
		Stdev	1.87	0.31	82.75	29.71	7.97

Water hardness is primarily the amount of calcium and magnesium and to a lesser extent, iron in the water and is commonly expressed as milligrams of calcium carbonate equivalent per litre. Water containing calcium carbonate at concentrations below 60 mg/L is generally considered as soft; moderately hard (60–120 mg/L), hard (120–180 mg/L) and very hard (>180 mg/L) (McGowan, 2000). The classification of groundwater of the study area (Table 1) based on total hardness (TH) revealed that 85% of the well water fell in the soft water category while the remaining 15% were in the moderately hard category. Water in the study area is suitable for domestic uses as shown by this classification.

Results of the chemical constituents (Table 2) revealed that Ca^{2+} ranged from 2.28 – 38.74 (av.9.57) mg/L, Mg^{2+} from 0.51 – 13.13 (av. 3.06) mg/L, Na^+ from 1.52 – 88.68 (av.18.18)mg/L and K^+ from 1.32 – 10.92 (av. 4.00) mg/L. Similarly, concentrations of HCO3- ranged from 15.25 – 61 (av. 36.60) mg/L, SO42- from 4.60 – 19.60 (av. 10.70)mg/L, Cl- between 72 and 432 (av. 160.65)mg/L and NO3- from 0.11 – 4.03 (1.58)mg/L. Well water samples analyzed in the study area exhibited an overall ionic dominance of $Na^+ > Ca^{2+} > K^+ > Mg^{2+}$ for the major cations on the one hand and $Cl^- > HCO_3^- > SO_4^{2-} > NO_3^-$ on the other hand. This order was in contrast with the ionic dominance for freshwater which is in the order of $Na^+ > Mg^{2+} > Ca^{2+} > K^+$ and $HCO_3^- > SO_4^{2-} > Cl^-$ for freshwater (Burton and Liss, 1976). This observation is a clear indication of variability from one location to other in the major factors (climate, lithology and anthropogenic) controlling chemical concentrations of groundwater. The result signified low mineralized water that is potable except in few locations (EKSU12, EKSU13 and EKSU14) where Concentrations of Cl- exceeded the approved WHO (2004) standard for drinking water due to local anthropogenic contamination. Excess concentration of chloride in drinking water gives a salty taste and has a laxative effect on people not used to it.

Table 2. Measured Chemical Parameters from the Study Area.

Code	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Mn (mg/L)	Fe (mg/L)	Zn (mg/L)	HCO_3 (mg/L)	SO_4 (mg/L)	Cl (mg/L)	NO_3 (mg/L)
EKSU1	5.65	1.28	9.1	3.63	0.03	0	0.022	30.5	5.20	180	0.94
EKSU2	3.2	7.8	6.01	1.32	0.01	0	0.025	30.5	9.80	108	0.68
EKSU3	16.62	4.97	25.34	7.77	0	0.14	0.031	30.5	11.40	90	0.34
EKSU4	3.28	0.65	4.75	5.68	0	0.31	0.026	15.25	19.60	126	0.85
EKSU5	10.82	1.06	1.65	1.86	0	0.39	0.023	15.25	12.60	108	0.35
EKSU6	3.5	0.83	1.52	3.3	0	1.3	0.04	15.25	17.00	72	0.11
EKSU7	9.51	0.51	3.22	2.79	0	0.3	0.025	45.75	8.00	135	3.03
EKSU8	6.57	0.74	2.45	3.04	0	0	0.078	45.75	7.90	108	0.7
EKSU9	38.74	0.82	2.86	5.08	0	0.32	0.05	30.5	16.00	108	0.25
EKSU10	3.36	1.05	8.12	1.67	0	0.72	0.024	45.75	8.40	144	1.97
EKSU11	5.27	0.64	28.57	2.75	0	0.13	0.035	30.5	8.30	117	1.37
EKSU12	5.26	7.56	47.58	8.38	0.05	0	0.019	61	12.20	279	2.64
EKSU13	5.7	7.67	43.55	6.24	0.02	0.37	0.033	61	5.30	414	3.66
EKSU14	27.14	13.13	88.68	10.92	0.03	0.31	0	61	4.60	432	4.03
EKSU15	4.09	3.52	24.35	2.3	0	0.09	0	30.5	11.80	180	1.69
EKSU16	3.41	4.1	30.54	3.3	0.09	0.1	0	15.25	15.20	234	3.07
EKSU17	9.5	0.71	4.45	2.26	0.03	0.02	0.405	61	6.70	90	0.48
EKSU18	21.97	0.9	16.24	3.5	0	0.17	0.021	30.5	15.30	90	0.91
EKSU19	5.48	1.54	8.26	2.1	0	0.02	0.013	45.75	8.40	126	2.57
EKSU20	2.28	1.75	6.43	2.03	0	0.21	0.034	30.5	10.30	72	1.87
Min	2.28	0.51	1.52	1.32	0.00	0.00	0.00	15.25	4.60	72.00	0.11
Max	38.74	13.13	88.68	10.92	0.09	1.30	0.41	61.00	19.60	432.00	4.03
Mean	9.57	3.06	18.18	4.00	0.01	0.25	0.05	36.60	10.70	160.65	1.58
Stdev	9.55	3.47	21.80	2.58	0.02	0.31	0.09	15.96	4.24	103.87	1.22

Few trace metals analyzed in this research including Fe, Mn and Zn fell within approved WHO (2004) standard values for drinking water except in few locations (EKSU4 (0.31mg/L), EKSU5 (0.39mg/L), EKSU9 (0.32mg/L), EKSU10 (0.72mg/L), EKSU13(0.37mg/L) and EKSU14 (0.31mg/L)) where the concentrations slightly exceeded the approved standard value of 0.3mg/L. Mn exceeded the approved standard value of 0.04mg/L in two locations (EKSU 12 and EKSU 16) while Zn concentrations were within the approved value of 3mg/L (WHO, 2004). The fact that the locations of these slight increases were close to one another is evidence that the contamination arose from localised anthropogenic activities. Trace metals in minute quantity are needed by the body to satisfy its nutritional requirements as high doses lead to health hazards which are sometimes lethal.

CHARACTERIZATION OF WELL WATER FROM THE STUDY AREA

Groundwater characterisation constitutes one of the vital tools for sustainable development and provides important information for water management. The characterization could be used to fitch out groundwater bodies that are at risk of failing to meet the approved water standards for domestic, industrial and agricultural purposes. The hand dug well water of the study area was classified from the analytical data for utilitarian purpose. To characterize the groundwater, the major ionic species obtained from the hydrochemical analyses were projected graphically on Piper Trilinear Diagram and the Schoeller Graph (Piper, 1944, Hem, 1991) using GW_Chart and Microsoft Office Excel Softwares respectively.

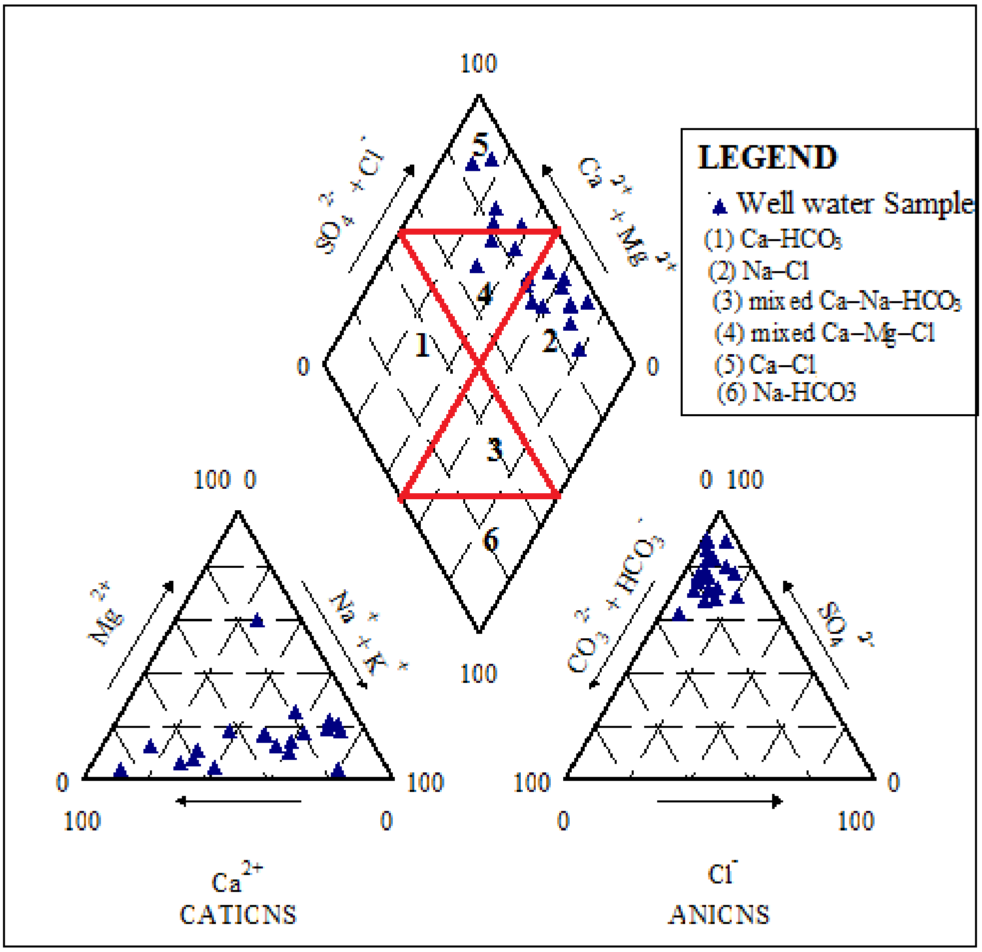

Fig. 2. Piper Diagram of Well Water Samples from the Study Area

Most of the Well water fell into Na-Cl water type (55%) followed by Ca-Cl (30%) and mixed Ca-Mg-Cl type (15%). The Piper diagram indicates that Na was found to be the most dominant cation in the hydrochemical facies of 20 water samples which was followed by Na and dominance of Cl reflecting anthropogenic activity. The result obtained from the Piper diagram is supported by the Schoeller Diagram (Fig. 3) indicating Na and Cl as dominant cation and anion in the well water of the study area respectively.

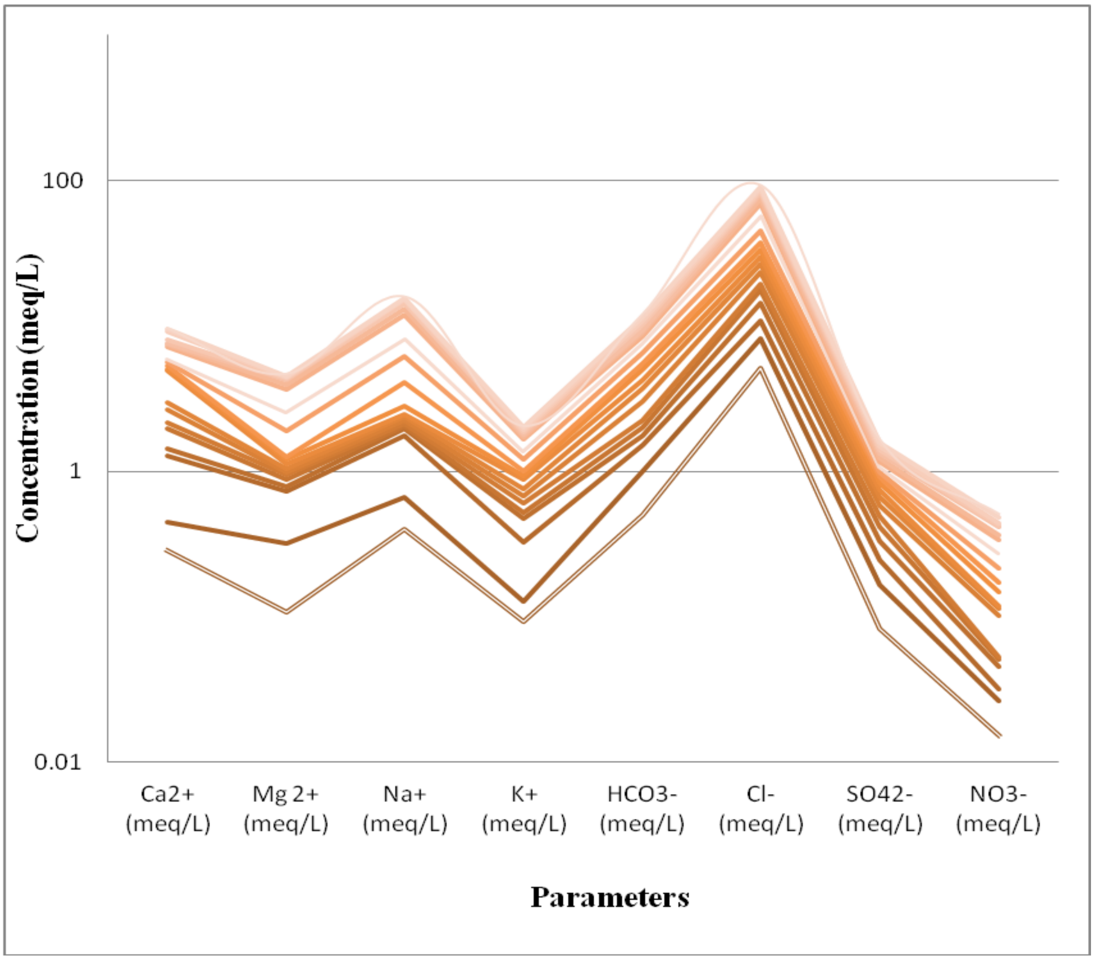

Fig. 3. Schoeller Diagram of Well water from the Study Area

CONCLUSION

This research on the physiochemical characteristics of hand dug wells water around Ekiti State University Ado-Ekiti, Southwest Nigeria revealed that all major ionic concentrations as well as the physical parameters (Temperature (°C), pH, EC (µS/cm) and TH(mg/L $CaCO_3$)) of the well water were within WHO(2004) approved standard values for drinking water except few locations (3 out of 20) in which Cl exceeded the value. The classification of groundwater of the study area based on total hardness (TH) classification of McGowan, (2000) revealed that 85% of the well water fell in the soft water category while the remaining 15% were in the moderately hard category. Well water samples analyzed in the study area exhibited an overall ionic dominance of $Na^+ > Ca^{2+} > K^+ > Mg^{2+}$ for the major cations on the one hand and $Cl^- > HCO_3^- > SO_4^{2-} > NO_3^-$ on the other hand. The well water were characterized as Na-Cl water type (55%) followed by Ca-Cl (30%) and mixed Ca-Mg-Cl type (15%). The research indicated that the well water is soft, low mineralized and potable.

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