Assessment Of Geochemical And Biological Composition Of The Subsurface Water Within Federal Polytechnic Ede And Environs, Osun State, Nigeria

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***Abstract*—Water is a vital and invaluable resource to the existence of all living organisms and the demand for good quality water for domestic and industrial purposes increase per day. However this valued resource is increasingly being threatened as human population and activities grow. Hence an assessment of the quality of subsurface and surface water is very important in evaluating its characteristics and utility in various fields. Thirty one water samples were systematically collected from some hand-dug wells, boreholes and streams within the federal polytechnic Ede and Ede town, Osun State with latitude 7042'N and 7042'N, and longitude 4042'E and 4027'E. The samples were analyzed in the laboratory for physical, chemical and biological composition in other to determine the water type or hydro-chemical facie, nature and trend of rock versus water reaction, potential pollutants, source of water, water mixing level and the quality and abundance of the elemental specie of the groundwater within the study area. Result from the laboratory analysis of the samples indicated concentrations of Ca^+ as (1.11 to 0.393mg/l), Na^+ (1.10 to 2.20mg/l), Mg^+ (0.35 to 98.70), K^+ (1.30 to 61.60), Mn+ (0.00 to 0.98), Fe2+ (0.11 to 0.68), Cu^{2+} (0.028 to 0.043), Zn^{2+} (0.001 to 0.006), Cd^{2+} (0.00 to 0.018mg/l), Pb^{2+} (0.148 to 0.435mg/l), Si (1.01 to 3.39mg/l), Ag^{2+} (0.14 to 0.48mg/l) and Total Dissolve Solute, TDS ranges from 18.37 to 228.8mg/l. Similarly Cl^-, SO_4^{2}-, NO_3^{2-} and HCO_3^- range from (43.2 to 316.8), (0.00 to 2.69), (0.00 to 10.30) and (0.00 to 61.0mg/l) respectively in concentrations. However the biological analysis indicated Coliform count (CFUs/g) ranging from 0.5 x 10^3 to 7.2 X 10^2, with species such as E. Coli, Aeromonas Sp, and Enterobacter Sp. Deductions from the concentrations value and analysis using Piper, Durov and Stiff models classified the waters within the study area into two water type: Ca^{2+} + Mg^{2+} and Cl^- + SO_4^{2-}, and Ca^{2+} + Mg^{2+} and $HCO_3^{-\ +}$ waters suggestive of alkaline water source of permanent hardness. Plotted concentrations at the middle of the Piper's diamond suggest water mixing which is also confirmed by high coliform counts which is above the WHO coliform count standard in some locations within the federal poly, Ede. Similarly evidence from the result as seen from the concentration and comparism with some standard shows water contamination in some hand dug wells and boreholes within the federal poly, Ede and environs due to high value of Pb^{2+}, Cd^{2+} and Coliforms levels above the WHO standard. The high concentration values of Pb^{2+} and Cd^{2+} is probably due to the dissolution and precipitation reaction that occurs between the rock type and ground water in the study area as suggested by the piper and Durov models, while the high coliform count is due to Pathogenic reaction and communication between organic decay or sewage source and groundwater system. Dissolved cations such as Ca^{2+}, Na^+ and K^+ fall within the recommended level suitable for drinking. However the abnormally high coliform index and some heavy metals such as Pb and Cd indicated from some of the samples collected within federal poly, Ede and environs pose some contamination treat and make such water unfit for health condition, laboratory and domestic uses without any standard treatment of such water. A further assessment of the groundwater and surface water of study area is essential after six month or a year in order to ascertain whether the high values of concentrations is really geogenic, pathogenic or due to any laboratory errors.**

***Keywords*—subsurface water; groundwater; E coli; pathogenic; assessment; quality**

I. INTRODUCTION

Water plays a key role in existing of all living organism. It determines the physical, mental and social health of any one (Yakubu and Baba, 2010). Water is one the most important elementary factors that plays a major role in the development of a society. While human senses can only analyze the aesthetic quality of water, it cannot go beyond that to ascertain the chemical quality of drinking water. As a result, the overall process of evaluating the physical characteristic and elemental concentration of heavy metals contained in drinking water is very important. For instance, unsafe drinking water contributes to numerous health problems in developing countries such as the one billion or more incidents of diarrhea that occur annually (Mark et al., 2002). While water may appear to be clear and pure, and has no specific taste or odor, it may contain elements that can have undesirable effects on health. Water is classified under two main categories based on its location and these are surface and groundwater (Appelo and Postma, 2005).

The study area is located in the Federal Polytechnic Ede campuses, North and South campuses and its environs with latitude N7º45'00" and N7º48'00" and longitude E4º25'00" and E4º28'00" of Iwo sheet 242 N.E within the basement complex of south western Nigeria, figure 1. The study area is easily accessible by the main road from Akoda and minor roads within the town, and as well as footpaths linking one sampling point to the other. The area is well drained by good network of rivers and streams (Fig 2) with the most prominent being River Awere, flowing roughly in north-south direction in a dentritic, tributaries and linear drainage pattern.

Rocks of the Precambrian basement complex of Nigeria underlay the study area, figure 2. The Precambrian basement of Africa can be divided into three large cratons; these are the Kalahari craton, Congo and West African cratons, separated from each other by a number of mobile belts active in late Proterozoic times. The Nigerian basement complex lies north-east of the Congo Craton in a mobile belt affected by the Pan African Orogeny. These rocks outcrop in two large areas (viz; the south-western and north-central parts of the country) and in smaller areas in the northeastern parts and the southeastern parts notably around the Oban massif and Obudu areas (Ekwueme, 2000). Three main lithologic groups are usually distinguished in the Nigerian basement. These are; A gneiss migmatite complex with evidences of polycyclic metamorphism mainly of amphibolites facies grade with. Archean and Pan African ages. A N-S trending schist belts of low grade sub-crustal rocks with minor volcanic assemblages. They are concentrated in the western half of Nigeria although minor occurrences have been noted in the northern eastern and southern eastern parts Syn-late tectonic Pan African granite, which are collectively termed Older Granites and intrude the schist belts and the gneiss migmatite complex.

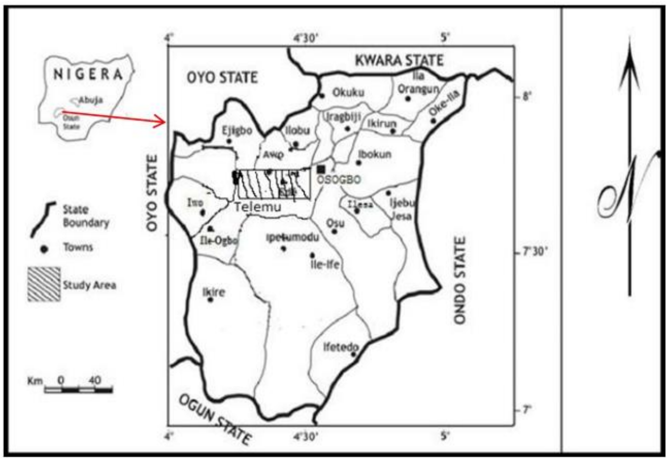

FIG 1: LOCATION MAP OF THE STUDY AREA

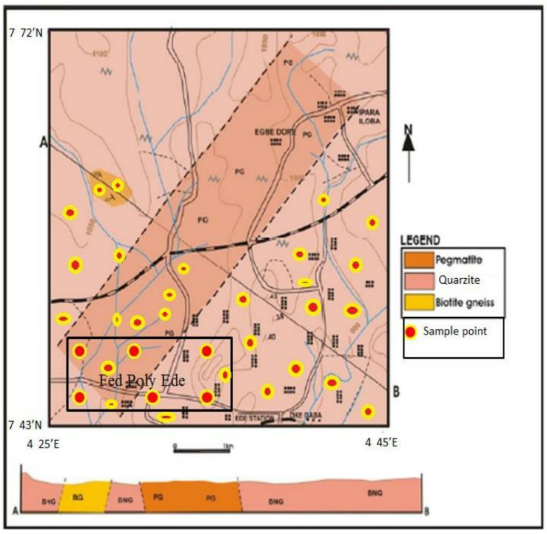

Fig 2: the Geological map of the study area showing the sample point.

II. HYDROLOGY AND HYDROGEOLOGIC SETTINGS

Nigeria is dominated by two great river systems, the Niger-Benue and the Chad systems. With the exception of a few rivers that empty directly into the Atlantic Ocean (Cross River, Ogun, Osun, Imo, Qua Iboe and a few others), all other flowing waters ultimately find their way into the Chad Basin or down the lower Niger to the sea

Ede metropolis is being underlain by crystalline Basement complex of south Western Nigeria which contains weathered overburden with low or little porosity and permeability due to low or lack of primary structures. The surface water flow in the area is mainly overland flow and runoff since water need high residence time to infiltrate. The rate of water infiltration and percolation is low due to the earlier mentioned factors and undulating topography of this area which allow precipitated water to run into various dendritic drainage and store in various rivers and lakes across Ede. These small tributaries join to form major rivers such as the Awere river found along south campus Federal Poly Ede.

III OBJECTIVE OF THE STUDY

The study aimed at:

- Determining the Physical, chemical and biological composition of the surface and subsurface water in the study area
- Determine the water type or hydro-chemical facie of the water in the study area
- knowing the nature of rock versus water reaction in the study area
- knowing the potential pollutants and the abundance of the elemental species in the water system of the study area
- knowing the source of water and water mixing level

IV METHODOLOGY

Over one hundred (100) Water samples were collected during the field work in Ede town and out of the samples collected twenty (20) boreholes samples, eight (8) hand-dug wells and three (3) stream water samples within Federal polytechnic Ede campuses and environs were sent to laboratory for hydro-chemical and biological analysis. A small plastic bottle of one (1) litre capacity rinsed with the water collected at each specific location was used to collect water samples. The collected samples were kept in a cool container for preservation and onward transportation to the laboratory for analysis. Water samples collected from the study locations were later taken to the laboratory for the physicochemical and biological analyses to deduce the following parameters:

Total dissolve solid (TDS), Electrical conductivity (EC), Chloride (Cl^-), Sulphate (SO_4^{2-}), Nitrate (NO_3^{2-}), Hydrogen carbonate (HCO_3^-), fecal coliform (FC) and total coliform (TC) counts. Cations such as Calcium (Ca^{2+}), Potassium(K^+), Sodium ($Na^{+`}$), cadmium (Cd^+), Iron (Fe^{2+}), Manganese (Mn^+), Zinc(Zn^{2+}) and Lead(Pb^{2+}) were analyzed using atomic absorption spectrophotometer (AAS).

V RESULT AND DISCUSSION

From the results of the analysis of water samples collected from various locations within the study area shown in the Table 1,2,3 and 4, it was observed that the concentration of Ca^{2-} ranges from 1.5 to 95.10 with average mean of 35.744mg/l. Mg^{2+} ranges from 0.32 to 8.04 with average mean of 4.7601mg/l. K^+ ranges from 3.03 to 61.60 with average mean of 14.462mg/l. Na^+ ranges from 1.00 to 1.60 with average mean of 1.26mg/l. Fe^{2+} ranges from 0.02 to 1.08 with average mean of 0.188mg/l. Mn ranges from 0.00 to 0.31 with average mean of 0.06mg/l. Zn^{2+} 0.002 to 0.013 with an average mean of 0.0056mg/l. Pb^{2+} ranges from 0.212 to 0.435 with average mean 0.3321mg/l. Cd have the concentration range of 0.00 to 0.018mg/l and with average mean of 0.006 and Si ranges from 0.05 to 2.90mg/l with mean of 0.407. For major anions, HCO_3^- ranges from 12.2 to 61.0 with an average mean of 34.37mg/l. Cl^- ranges from 43.2 to 316.8 with average mean of 176.74mg/l. SO_4^{2-} ranges from 0.00 to 2.69 with average mean of 0.789mg/l and NO_3^{2-} ranges from 0.00 to 10.300mg/l with average mean of 0.18mg/l. On the other hand, result of the microbiological analysis is shown in Table 8. The analysis shows *E-coli* bacteria in two samples. On the other hand, the total coliform bacteria count in all the water samples ranges from 500 to 1500 colony forming units (CFUS/ml). This gives credence to the presence of contaminant bacteria in the water samples. The total coliform test is the basic yardstick for determining a water supply's biological quality. This test is performed frequently because of the risk that disease-causing organisms pose to health. The test is easy to perform, inexpensive, and errs on the side of caution.

Table 1: Hydro-chemical data of water samples from the study area (Mg/L).

S/N	ID	Ca	Mg	K	Na	Fe	Mn	Zn	Pb	Cd
1	Boys Hostel Borehole,L1	2.94	8.04	61.60	1.20	0.02	0.01	0.004	0.232	0.00
2	Girls' Hostel Borehole,L2	1.50	1.40	28.40	1.10	0.02	0.01	0.005	0.212	0.00
3	Adeleke University Cafeteria's Borehole,L3	28.40	0.32	3.74	1.40	0.03	0.01	0.010	0.314	0.00
4	Adeleke University School of Performing Art Borehole,L4	32.90	1.73	5.71	1.20	0.06	0.07	0.004	0.325	0.00
5	Fed. Poly School Medical 1 hand-dug well, L5	77.40	7.90	18.40	1.10	0.05	0.01	0.002	0.393	0.00
6	Stream along Basic science Adeleke University, L6	34.50	0.48	3.03	1.00	1.08	0.17	0.005	0.346	0.00
7	Agbale small gate 3 Hand dug well, L7	32.90	0.49	5.66	1.30	0.15	0.01	0.013	0.343	0.00
8	Hand Dug well at Civil Engineering Fed. Poly, L8	95.10	23.15	6.67	1.60	0.16	0.00	0.003	0.376	0.00
9	Old Rombay 2 well hand dug well, L9	26.70	3.741	8.21	1.40	0.18	0.31	0.006	0.345	0.00
10	Female Hostel Borehole Adeleke University, L10	25.10	0.35	3.20	1.30	0.13	0.00	0.004	0.435	0.00

Table 2: Hydro-chemical data of water samples from Federal Polytechnic Ede within the study area.

S/n	ID	Ca	Mg	K	Na	Fe	Mn	Cu	Zn	Pb	Cd	Si	TDS
1	B.Multi,	2.66	1.08	3.98	2.30	1.46	0.02	0.127	0.287	0.000	0.005	0.28	0.02
2	W.Multi,	4.32	0.40	5.64	1.70	2.11	0.04	0.064	0.753	0.000	0.008	0.09	0.00
3	B.GEO,	1.22	1.43	4.39	1.70	1.92	0.02	0.133	0.135	0.026	0.009	0.10	0.01
4	S. Geo,	13.90	0.04	8.84	1.90	4.74	0.04	0.131	0.150	0.000	0.005	0.05	0.03
5	B. Muse,	1.74	0.37	6.43	2.0	0.30	0.06	0.112	0.990	0.000	0.004	0.25	0.00
6	W.Mese,	1.40	0.79	5.65	1.80	2.56	0.18	0.109	0.127	0.000	0.008	0.19	0.01
7	B. Med,	1.81	1.31	2.07	1.80	0.56	0.01	0.05	0.099	0.000	0.002	0.07	0.16
8	W. Med,	64.00	7.95	9.90	2.30	0.43	0.01	0.099	0.086	0.000	0.002	0.15	0.00
9	B. work,	42.5	11.52	4.94	2.40	1.85	0.10	0.132	0.229	0.000	0.003	0.20	0.03
10	W.Work,	6.24	4.58	5.78	1.70	24.40	0.03	0.100	0.382	0.000	0.006	0.20	0.01
11	B Mosq,,	2.80	91.2	2.30	2.10	0.13	0.14	0.043	0.003	0.319	0.018	2.90	78.3

The groundwater in the crystalline basement area is generally found within the weathered overburden (regolith) and structural traps. During their transportation from precipitation to runoff, infiltration and flow through pore spaces of faults and joints, they undergo hydro-chemical transformations as a result of interaction with the medium through which it flows. The calcium and chloride concentration are found to be high in almost all the water samples from the study area, sources of calcium could be from weathering and alteration of calcium rich olivine and pyroxene minerals within the Basement complex rocks. Magnesium, however show broad bands on scatter plot with chloride and bicarbonate (fig 6), this is an indication that bicarbonate in the water originated from dissolution of carbon dioxide from exhaust of automobile, electricity generators, and other combustion engine which later react with the mineral in the soil. This is an indication that the hydrochemistry of groundwater in the study area is not only controlled by base exchange through weathering and dissolution but also with salinization judging from coefficient value 0.0557 and 0.3421 (fig 6) as observed in Abimbola et al, 1999. Silicate weathering also causes significantly higher silica content in the groundwater derived from crystalline rock. Chemical data of representative samples from the study area presented by plotting them on a Piper tri-linear diagram (Fig 3) reveal the analogies, dissimilarities and different groups of water in the study area and identified with 80% of the water samples plotting on the "calcium type" hydrochemical facies, while the other 20% fall within the

"Sodium/Potassium type" hydrochemical facies (from Kehew 2001) at the Cations ternary plot (Figure 4). The Anions ternary plot (Figure 4) show that, all the water samples in all the sampled locations fall within the "chloride type" hydrochemical facies (from Kehew 2001). The projected Diamond shaped plot, shows 80% of the samples plotted on Ca+Mg, Cl+SO4 facies and 20% plotted on Cl+SO_4^{2-}, HCO_3 facies. (Kehew 2001).

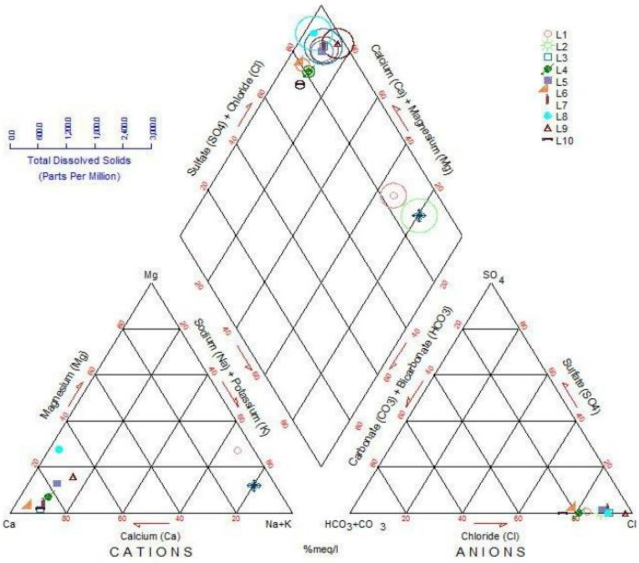

Fig. 3: Piper Diagram showing the chemistry of the of the water samples from the study area.

Note that samples L11 to L21 plotted in the same region as L1 to l10 in fig 3 and fig 4. Similarly L11 to L12 show same concentration pattern as L1 to L10 in fig 5.

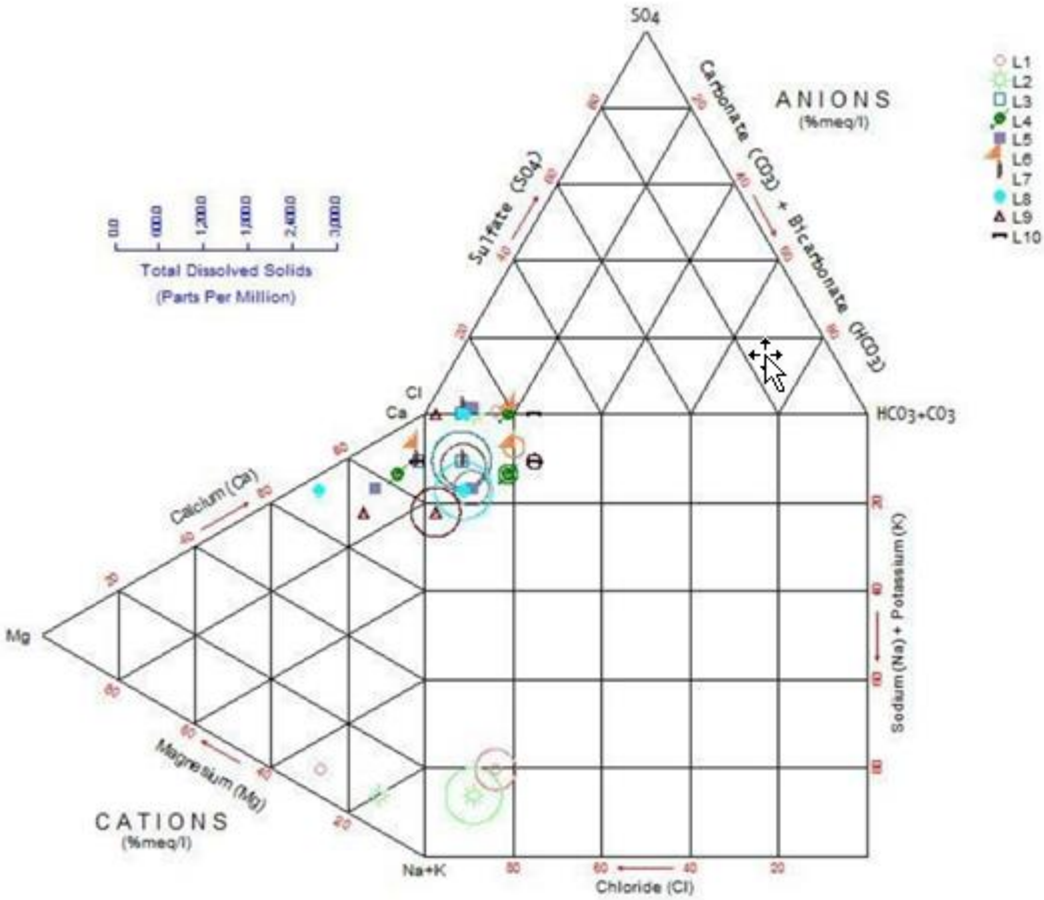

Fig.4: Durov Diagram which demonstrate the hydro-chemical relationship among ions in the water within the study area

Table 3: Solute and Anion Concentration of the water samples from within and outside the campus within the study area

S/N	ID	TDS mg/l	Conductivity µs/cm	Cl^- mg/l	SO_4^{2-} mg/l	NO_3^{2-} mg/l	HCO_3 mg/l
1	.L1	228.0	304	151.2	1.41	0.70	48.8
2	L2	219.8	293	288.0	0.68	0.40	61.0
3	L3	215.3	287	316.8	1.01	0.30	48.8
4	L4	217.5	290	61.2	0.08	0.20	24.4
5	L5	227.3	303	108.0	2.69	0.00	20.4
6	L6	214.5	286	72.0	1.59	0.00	30.5
7	L7	217.5	290	223.0	0.08	0.00	36.6
8	L8	228.8	305	223.2	0.35	0.00	36.6
9	L9	222.8	297	280.8	0.00	0.10	12.2
10	L10	215.0	287	43.2	0.00	0.10	24.4

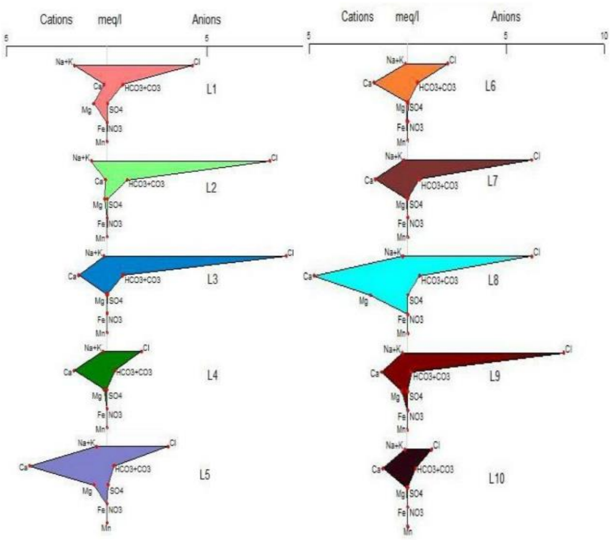

Fig.5: Stiff Diagram for ground water ion concentration pattern within the study area.

The Durov Diagram is an alternative to the Piper Diagram. In the two triangles, it plots the major ions as percentages of milliequivalents (Figure 4). The total of both the cations and anions are set to 100% and the data points in the two triangles are projected onto a square grid which lies perpendicular to the third axis in each triangle. Total Dissolved Solids (TDS) values are depicted with proportionally scaled circles, similar to those in the Piper Diagram program. In figure 4, the ions plotted in the ion exchange region suggesting the groundwater to have undergone an ion exchange reaction with the geology of the area. Stiff diagrams plot of milli-equivalent concentrations of cations on the left side of the diagram and of anions on the right (Figure 5). Each ion was plotted as a point, and the points were connected to form a polygonal shape. The ions were plotted in a consistent order (Na+K across from Cl; Ca across from HCO3 + CO3; Mg across from SO4) so that each polygon becomes that sample's "signature". Additional ions were plotted in the order that they are listed, below the standard ions.

VI STATISTICS OF THE PHYSICO-CHEMICAL PARAMETERS OF THE WATER SAMPLES FROM THE STUDY AREA

The statistical summary of the field measurement and wells sampled, presented in the Table 5 and 6 indicates the elevation of the study location to ranges from 884 to 1094ft with average mean of 997.4ft and the value of the electrical conductivity (EC) and total dissolved solid to range from 287 to 305µs/cm and 214.5 to 228.8mg/l respectively.

VII MICROBIAL STUDY OF THE WATER SAMPLES FROM THE AREA

The total approach in groundwater quality characterization includes all such factors of chemical and biological importance. More often than not the chemical component has dominated water quality assessment; however, this is incomplete without taken into account the biological component. The biological component is indicated by the presence of microbial organisms or pathogens in water samples. Accordingly, their presence in water sources depends on a number of factors including intrinsic physical and chemical characteristics of the catchment area and the magnitude and range of anthropogenic activities that release pathogens to the environments. It is upon this that microbial analysis was carried in the study area. Ede metropolis is notorious for high intensity human activities and poor environmental sanitation. Thus, this makes the microbial analysis important as an indicator of level of contamination. A total number of ten (10) water samples were analyzed for the microbial load, measured in MPN/ml (Most Probable Number/millilitre). As an indicator of contamination, the faecal coliform count (FC) or the *E-coli* bacteria were tested for. Also, the total coliform count (TC) was tested. The result of the analysis is shown in Table 8. The analysis shows *E-coli* bacteria in two samples. On the other hand, the total coliform bacteria count shows presence in all the water samples ranging from 500 to 1500 colony forming units (CFUS/ml). This gives credence to the presence of contaminant bacteria in the water samples. The total coliform test is the basic yardstick for determining a water supply's biological quality. This test is performed frequently because of the risk that disease-causing organisms pose to health. The test is easy to perform, inexpensive, and errs on the side of caution.

Total Coliform as an Indicator Organism

Coliform bacteria are a large assemblage of various species of bacteria. Some of the members of this group of microbes are found in natural environments: soils, plants, and surface water. Other types of coliform bacteria exist in the intestines of humans and other warm-blooded animals and are typically present in the fecal material from the host organism. It is this group of bacteria that is of significance during the water analysis because it is used as an indicator of bacterial contamination in drinking water. Any food or water sample in which this group of bacteria is found has potentially come in contact with domestic sewage, animal manure, or contaminated soil, plant, or animal material. Outside the host, bacteria die off quickly, typically within 30 days. Therefore, if coliform bacteria are seen in a well over a long period of time, it may be assumed that new bacteria are entering the well or aquifer (a natural underground water supply). It follows that such a water supply may contain pathogenic bacteria and viruses, which cause such serious human illnesses as typhoid fever, dysentery, hepatitis, etc. When present, coliform bacteria indicate the possibility, but not a certainty, that disease organisms may also be present in the water. When absent there is a very low possibility of disease from the water.

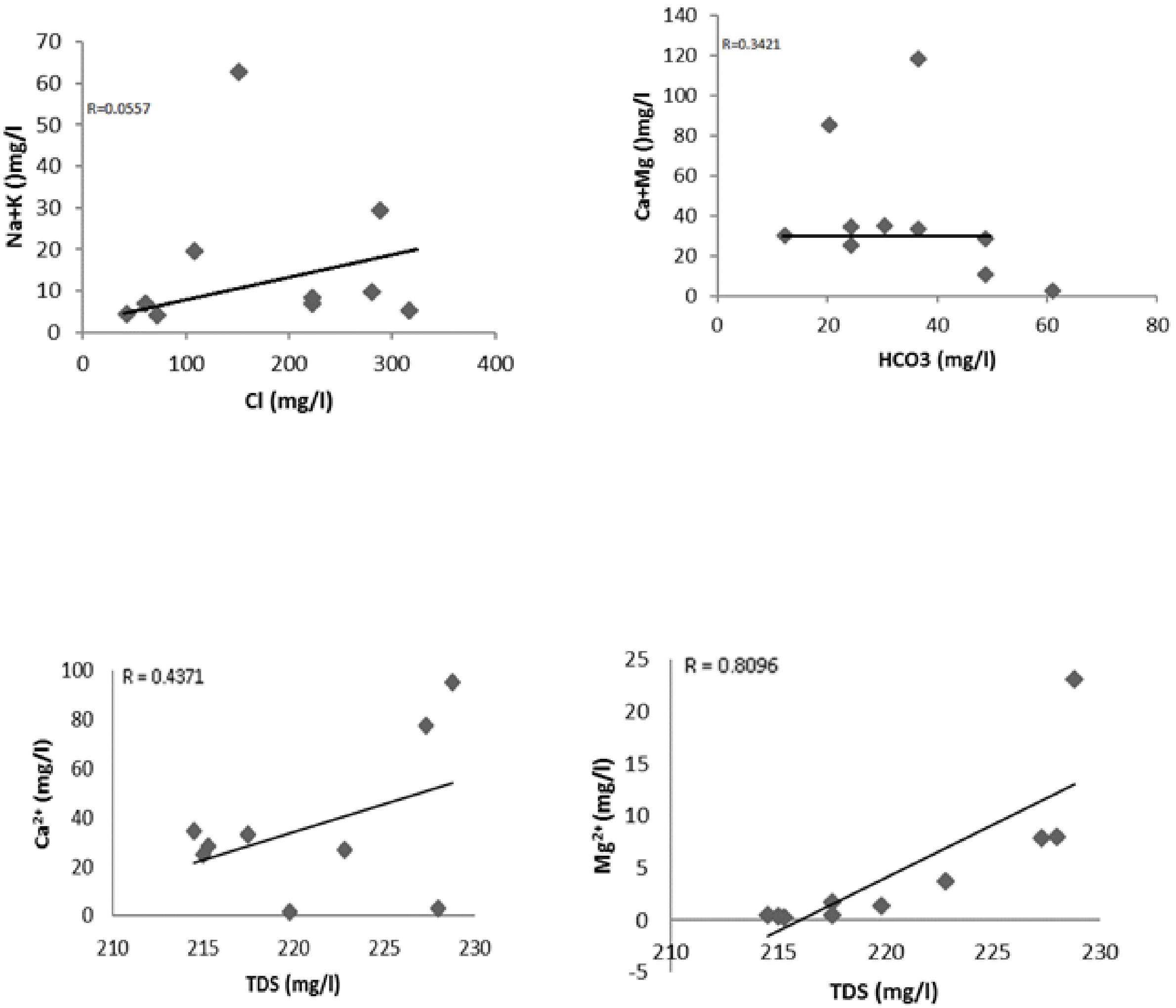

Fig 6: Scatter plots of major ions

Members of the Total Coliform Family and the risk associated with them

There are a number of subgroups within the overall coliform family as shown in the diagram on the right. The presence of bacteria from each progressively smaller subgroup heightens the concern that disease-causing organisms may be present in the water. These groups and their relative risk implications are discussed below.

Total Coliform

These organisms are very prolific in the soil and their presence does not necessarily imply poor wastewater disposal or other sanitation based health risks. The presence of only total coliform generally does not imply an imminent health risk but does require an analysis of all water systems facilities and their operation to determine how these organisms entered the water system. "Public notice" to public water system users is required since a properly constructed and properly maintained water system should not have total coliform present.

Faecal Coliform

This is a much smaller group within the total coliform family. Fecal coliform generally originate in the intestines of mammals. They have a relatively short life span compared to more general coliforms. Their presence could be related to improper disposal of sanitary waste. Immediate "public notice" and a boil order to the users (within 24 hours) are required due to the higher perceived risk of disease organisms also being presence in the water.

Escherichia Coli (e-coli)

This is a specific species (subgroup) within the coliform family. They originate only in the intestines of animals and humans. Like faecal coliform they have a relatively short life span compared to more general coliform. Their presence indicates a strong likelihood that human or animal wastes are entering the water system. Immediate "public notice" and a boil order (within 24 hours) are required due to higher perceived risk of disease organism also being present in the water.

The ability of the total coliform test to reliably predict the bacterial safety of water relative to the hundreds of possible diseases that might be present is critical since it impossible to check separately for every disease organism directly on a monthly or quarterly basis. Recently however, public health experts have recognized that certain protozoa, which cause disease, such as giardia and cryptosporidium, can be present in surface water even when the total coliform test shows absence. Although an important exception, the total coliform test remains the standard for determining the bacterial quality of drinking water in the world.

According to WHO standards (fig 7), faecal coliform must not be present in any 100mg/l of water sample. Total viable count should not exceed 100cfu/100ml.

Thus the presence of microbes in the Ede water samples makes them really a thing of water quality concern, even though the bulk of the samples were within the WHO Standard (fig 7).

VIII CONCLUSION

Hydro-chemical, hydro-geochemical and bacteriological assessment of overburden water and fracture of underlain lithology and shallow groundwater of Ede North and South and its environment have been comprehensively studied. Groundwater characterization using Piper (1944), Durov (1983) and some statistical method revealed Ca+ Mg, Cl + SO4 facies and Cl+SO4, HCO3 facies. (Kehew 2001).High chloride in some of the water was as a result of addition by some indigenes of Ede of a chlorine base disinfectant popularly known as water guard in their wells to reduce or eliminate germs. Low Nitrate in the groundwater indicates high level of attenuation of contaminated water by soil due to its high fine contents during infiltration and underground water movement. All the dissolved cations such as calcium, magnesium, sodium and potassium of the well water studied conformed with the recommended maximum limits. Also, one can conclude that Potassium ions calcium and magnesium ions concentration exists at level suitable for drinking. High coliform count in water wells was as a result of bacterial or viral contamination from human sewage or animal manure. Most of the hand-dug well water samples in the vicinities of pollution source and those in the residential areas contained Pb, Cd, and coliform levels (FC and TC) above the WHO stipulated limits for potable water. The high coliform index, increased metal levels and organic loads of the water samples were indices of pollution from leakages, seepages and run offs of the polluted environment where these wells were located. Based on the results, the groundwater resource, without standard treatment is unfit for drinking and domestic uses.

Table 4: Solute and Anion Concentration of the water samples mainly from federal polytechnic Ede campus of the study area

S/N	I.D	Hco_3^- mg/l	Co_3^- mg/l	So_4^{2-} mg/l	No_3^{2-} mg/l	TDS
1	L11	48.8	0.00	1.01	10.30	215.3
2	L12	24.4	0.00	0.08	0.20	217.5
3	L13	20.4	0.00	2.69	0.00	227.3
4	L14	30.5	0.00	1.59	0.00	214.5
5	L15	36.6	0.00	0.35	0.00	228.8
6	L16	12.2	0.00	0.00	0.10	222.4
7	L17	19.8	0.00	0.25	0.10	212.5
8	L18	20.5	0.00	0.26	0.00	225.4
9	L19	35.4	0.00	0.20	0.20	219.0
10	L20	30.3	0.00	2.30	0.10	223.4
11	L21	21.5	0.00	0.25	0.20	221.6

Table 5: Descriptive statistics of the Physico-Chemical properties of groundwater within the study area

PARAMETERS	MINIMUM	MAXIMUM	MEAN	STD. DEV.
TDS	214.50	228.80	221.25	5.659064
EC	287.00	305.00	294.20	7.495184
ELEV.	884	1094	997.4	67.07574

Table 6: Descriptive statistics for for major ions in groundwater within the study area

PARAMETERS	MINIMUM	MAXIMUM	MEAN	STD. DEV.
Ca^{2+}	1.50	95.10	35.744	29.38983
Mg^{2+}	0.32	8.04	4.761	7.118302
Na^+	1.00	1.60	1.260	0.177639
K^+	3.03	61.60	14.462	18.43344
HCO_3^-	12.20	61.00	34.370	15.04069
Cl^-	43.20	316.80	176.740	102.5524
SO_4^{2+}	0.00	2.69	0.789	0.890998
NO_3^-	0.00	0.70	0.180	0.229976

Table 7: WHO water quality standard (1997)

SUBSTANCE	UNDESIRABLE THAT MAY BE PRODUCED	HIGHEST DESIRABLE LEVEL	MAXIMUM PERMISSIBLE LEVEL
Total Dissolved solid (TDS)	Causes staining, or a salty, bitter taste	500mg/l	1500mg/l
Calcium	Excessive scale formation	75mg/l	75mg/l
Chloride	Tastes	200mg/l	250mg/l
Iron	Taste, discoloration, deposits turbidity	1.0mg/l	1.0mg/l
Lead	Nervous disorder and mental impairment especially in fetus and infant; kidney damage; hypertension	0.01mg/l	0.01mg/l
Magnesium	Irritation in the presenceof sulphate	20mg/l	20mg/l
Manganese	Taste, iscoloration, deposits turbidity	0.1mg/l	0.4mg/l
Sulphate	Gastor intestinal irritation when magnesium or sodium ions are present	250mg/l	500mg/l
Nitrate	Methaemoglobanenia (blue baby disease) in infants (birth-6 months)	10mg/l	50mg/l

Table 8: Microbial analysis result of water samples from the study area

S/N	ID	Coliform count (CFUS/ml)	Organisms Identified	E. Coli
1	Boys Hostel Borehole	0.9×10^3	Proteus sp	None
2	Girl's Hostel Borehole	1.1×10^3	Aeromonas sp	None
3	Cafeteria Adeleke University Borehole	1.0×10^3	Aeromonas sp	None
4	School of performing Art (Adeleke University) Borehole	0.9×10^3	Aeromonas Sp	None
5	School medical 1 (fedepe) hand dug well	0.5×10^3	Proteus sp	None
6	Adeleke University 1 (along basic science stream)	0.7×10^3	Enterobacter sp	None
7	Agbale small gate 3 Hand dug well	1.2×10^3	Enterobacter sp	None
8	South campus hand dug civil engineering well	1.1×10^3	Enterobacter sp	None
9	Old Rombay 2 well hand dug well	1.3×10^3	Proteus sp	1.3×10^2
10	Adeleke University Female Hostel Borehole	1.5×10^3	Aeromonas Sp	1.0×10^2

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