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Groundwater Quality Appraisal of Some Hand-Dug Wells and Boreholes around Okemesi and Ikoro Area, Southwestern Nigeria

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GROUNDWATER QUALITY APPRAISAL OF SOME HAND-DUG WELLS AND BOREHOLES AROUND OKEMESI AND IKORO AREA, SOUTHWESTERN NIGERIA

Strictly as per the compliance and regulations of :

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I. Introduction

Water is essential for survival of all living things. With world's population growing rapidly, water resources of the world is one of its most important assets. A large percentage of the mass of living organisms is made up of water. The quality of water is of vital importance whether for industrial or domestic purposes. For water to be of consumable quality, it must attain a certain degree of purity. According to Davis and De Wiest (1966), drinking water standard are based on two main criteria namely; the presence of objectionable taste, odour and colour; and the presence of substances with adverse physiological effects. However, mineral enrichment from underlying rocks can change the chemistry of water, making it unsuitable for consumption (Ako et al. 1990).

Water can also be a source of serious environmental and health problems if the design and development of such water supply system is not coupled and tied with appropriate sanitation measures. According to Oloke (1997), drinking water can act as a passive means of transporting nutrients into the body system. However, the objectives or primary concern in providing potable water are freedom from harmful micro-organisms and freedom from undesirable or harmful chemicals. Therefore, both the physiochemical and bacteriological assessment of potable water is of paramount importance and monitoring must be given the highest priority. A lot of literatures abound on groundwater prospecting and development in the basement complex such as Jones and Hockey (1965), which worked on groundwater prospect in the basement complex rocks of south western Nigeria and concluded that beneath the veneer of regoliths, the fresh basement rocks are highly fractured at shallow and greater depth. The crystalline basement complex rocks and their weathered derivatives constitute large reservoirs of groundwater which can yield considerable amount of water for human consumption especially in the areas where the overburden (soil) are sufficiently thick, porous and permeable enough to allow migration and accumulation of groundwater. Davis and De-Wiest (1966) revealed that crystalline rocks are poor water bearing aquifers because of their low porosity and low permeability except when secondary structures developed as a result of tectonic activities, selective dissolution of mineral grains and weathering. Azeez (1972), divided SW Nigeria into eight hydrogeological provinces and Odeyemi et al (1985), examined the remote sensing of rock fractures and groundwater development in parts of south-western Nigeria. However, this study focuses on water quality assessment by determining the physical, chemical and bacteriological properties of water from hand dug wells and boreholes around Ikoro and Okemesi area, Southwestern Nigeria with the objective of assessing its quality for human consumption and domestic usage.

The study area falls within the basement complex of southwestern Nigeria. Ikoro Ekiti in Ijero local government area of Ekiti State lies within latitudes 7°65' N and 8°00' N of the equator and longitudes 4°75' E and 4°95' E of the Greenwich meridian while Okemesi Ekiti in

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Ekiti west local government area of Ekiti State lies within latitudes 7°55' N and 7°80' N of the equator and longitudes 4°55' E and 4°59' E of the Greenwich meridian. The study area also lies north east of Ilesha in Osun State (Fig.1).The type of human settlement in the study area is the linear type in which houses and buildings are constructed along major roads following a regular pattern.

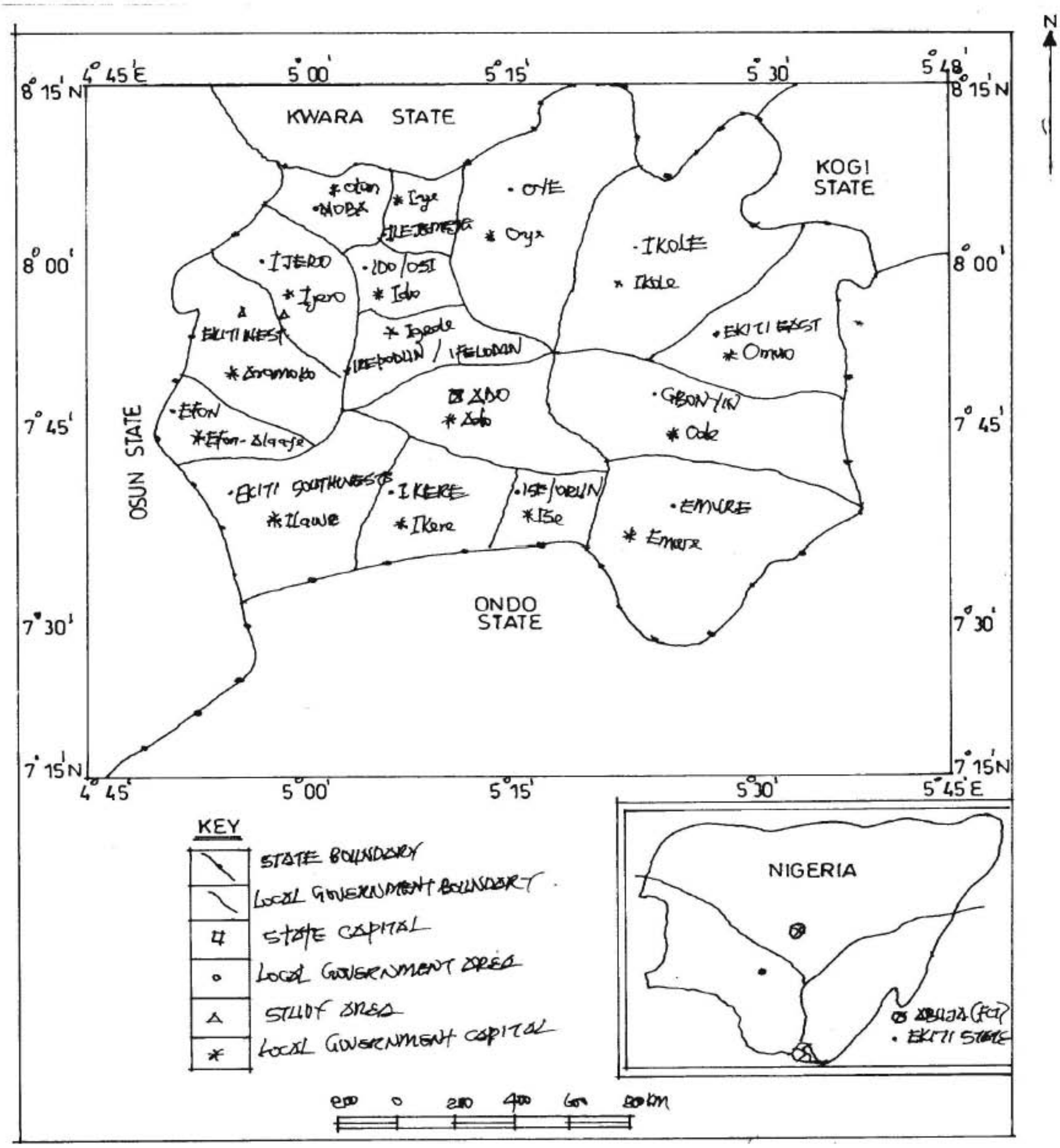

Fig.1 : Map of Ekiti State showing the study areas (Inset: map of Nigeria showing the study area.

II. Topography and Drainage

The topography of the study area is rugged with series of highlands, lowlands and massive rocks. The major topographic landform within the area is the ridge system formed by quartzite exposures that have undergone varying degrees of weathering and are characterised by undulating landforms. Trellis drainage pattern is in existence in the study area and majority of the rivers flow north-southwards and are structurally controlled. They get dried up during the dry season because their tributaries are seasonal but the major river is perennial. The major river that runs through this area is river oshun, which flows from highlands to relatively lowlands. (Fig.2)

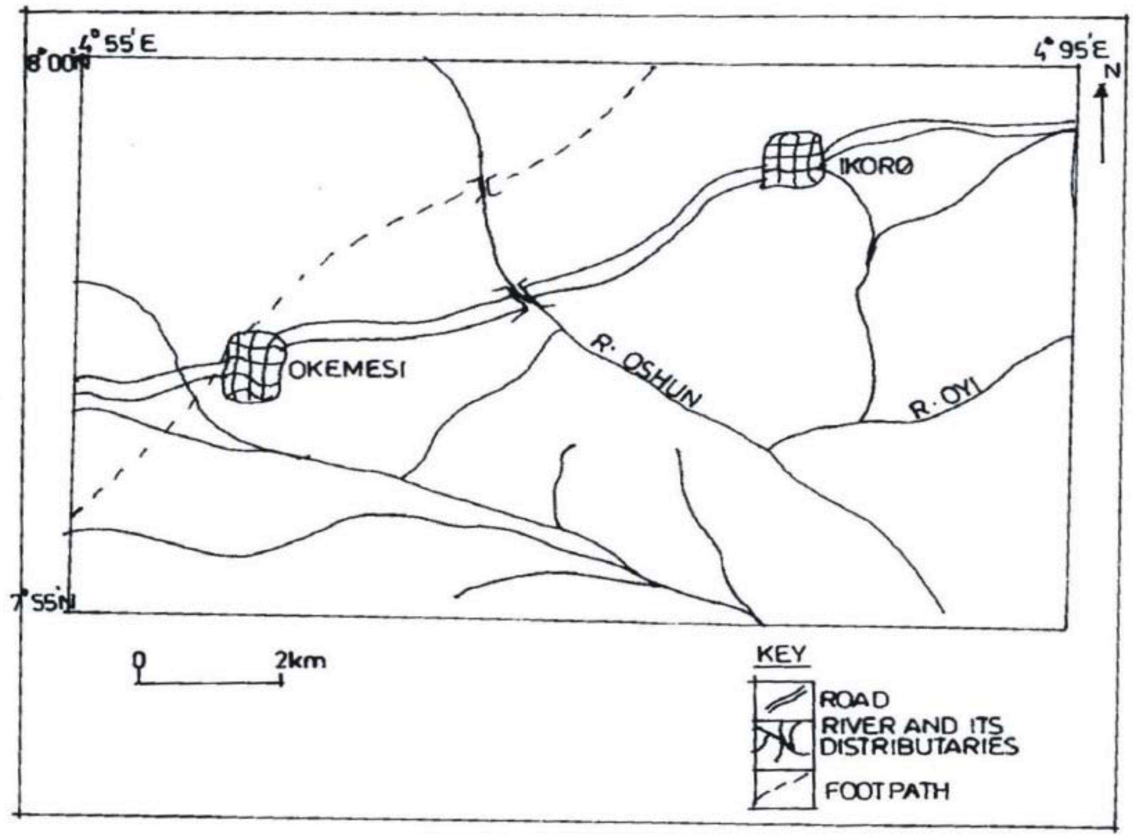

Fig.2 : Trellis drainage pattern of the study area

III. Geologic Setting of the Study Area

The study area belongs to the basement complex terrain of southwestern Nigeria (Fig.3) and lies within the Ilesha schist belt. The basement complex rocks are Precambrian in age although the rocks are also found in the early Paleozoic. The basement complex of southwestern Nigeria lies to the rest of the West African craton in the region of late Precambrian to early Paleozoic orogenesis. Structurally, the Precambrian geology of Nigeria lies within the structural framework of Africa and this can be divided into cratons and Pan-African mobile belts. The Nigeria basement complex extends westwards and is continuous with the Dahomeyan of the Dahomey-Togo-Ghana region. To the east and south, the basement complex is covered by the Mesozoic-Recent sediments of the Dahomey and Niger coastal basins. The West African craton and the Pan-African events which present the framework of West Africa in the igneous/ metamorphic structural framework of Africa consist of Precambrian rocks that have been subjected to major supra-crustal plutonic events. These events are;

i. Leonian 3000Ma
ii. Liberian 2500-2700Ma
iii. Eburnean 1850±250Ma
iv. Kiberian 1150±100Ma
v. Pan African 600±150Ma
vi. Harcynian 300Ma
vii. Alpine orogeny of the Atlas Mountain

The rocks of the Precambrian basement complex of Nigeria have been grouped into four lithologic units by Dada (2006) as follows:

(i) Migmatite-Gneiss-Quartzite Complex;
(ii) The schist belts
(iii) Pan African Granitoids and;
(iv) Unmetamorphosed minor acid and basic rocks

IV. Local Geology of the Study Area

Ikoro and Okemesi Ekiti lie within the south-western part of Nigeria basement complex (Figs 4 and 5). The dominant rock type in the study area is the quartzites of the Effon Psammite formation which occurs mostly as massive quartzites, schistose quartzites and quartz schists. The Effon Psammite formation (Hubbard, 1966; De Swardt, 1953; Dempster, 1967) is a belt of quartzites, quartz schists and granulites which occur largely east of Ilesha and runs for nearly 180km in a general NNE-SSW direction. This environment like other areas within the Nigeria basement complex was subjected to the Pan African orogenic event about 600±150Ma (Ajibade et al, 1980). The abundance of quartzite exposure in the study areas could by no means be a strange occurrence because of the proximity of this locality to Efon-Alaaye Ekiti popularly known for the Effon Psammite formation. Rahaman (1976) gives a general description of the mineralogy of the quartzites found in the southwest as being dominated by eight minerals where three or four are usually present such as quartz, muscovite, hematite etc. The colour of the quartzites found within the study area varies for instance, the schistose types are pure and white in colour, and the ferruginous ones exhibit a grey colouration when the samples are fresh but display brownish colouration when weathered. The different lithologies in the study area have been subjected to deformation which led to the development of synformal structures on the metamorphic rocks. The well pronounced structures include fractures, foliations, veins e.t.c. The general trend of the folds and foliations in the area is NNE-SSW direction (G.S.N. sheet 61 Akure). Rocks found in Ikoro Ekiti include charnockites, quartzites, schists, schistose quartzites and biotite gneisses while those of Okemesi include quartzites, schistose quartzites, migmatites and paraschists. These rocks with their associated meta- igneous rocks have been migmatized to various degrees. Also, the granites exhibit both intrusive and replacement characteristics in the area under investigation. The charnockites form an elongated N-S trending and they range from fine grained to coarse grained rocks of charnockitic affinities and from fine grained to coarse grained porphyritic granites.

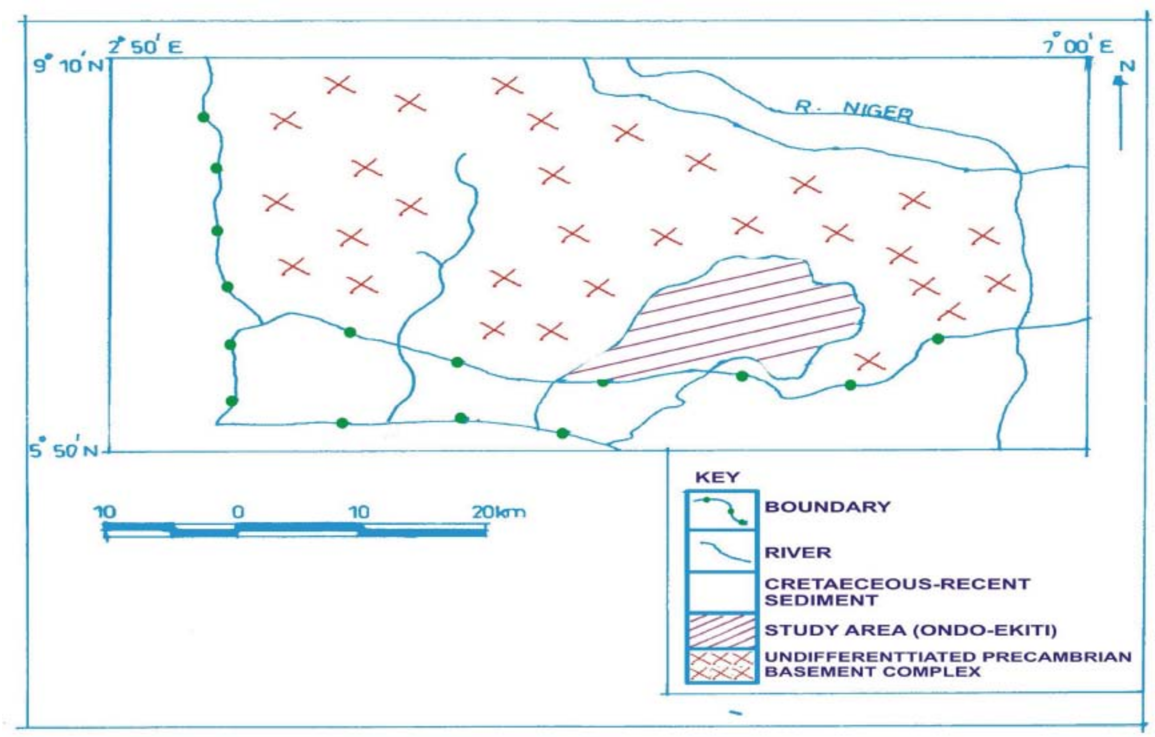

Fig.3 : Geological map of southwestern Nigeria (Adapted from Kogbe, 1976)

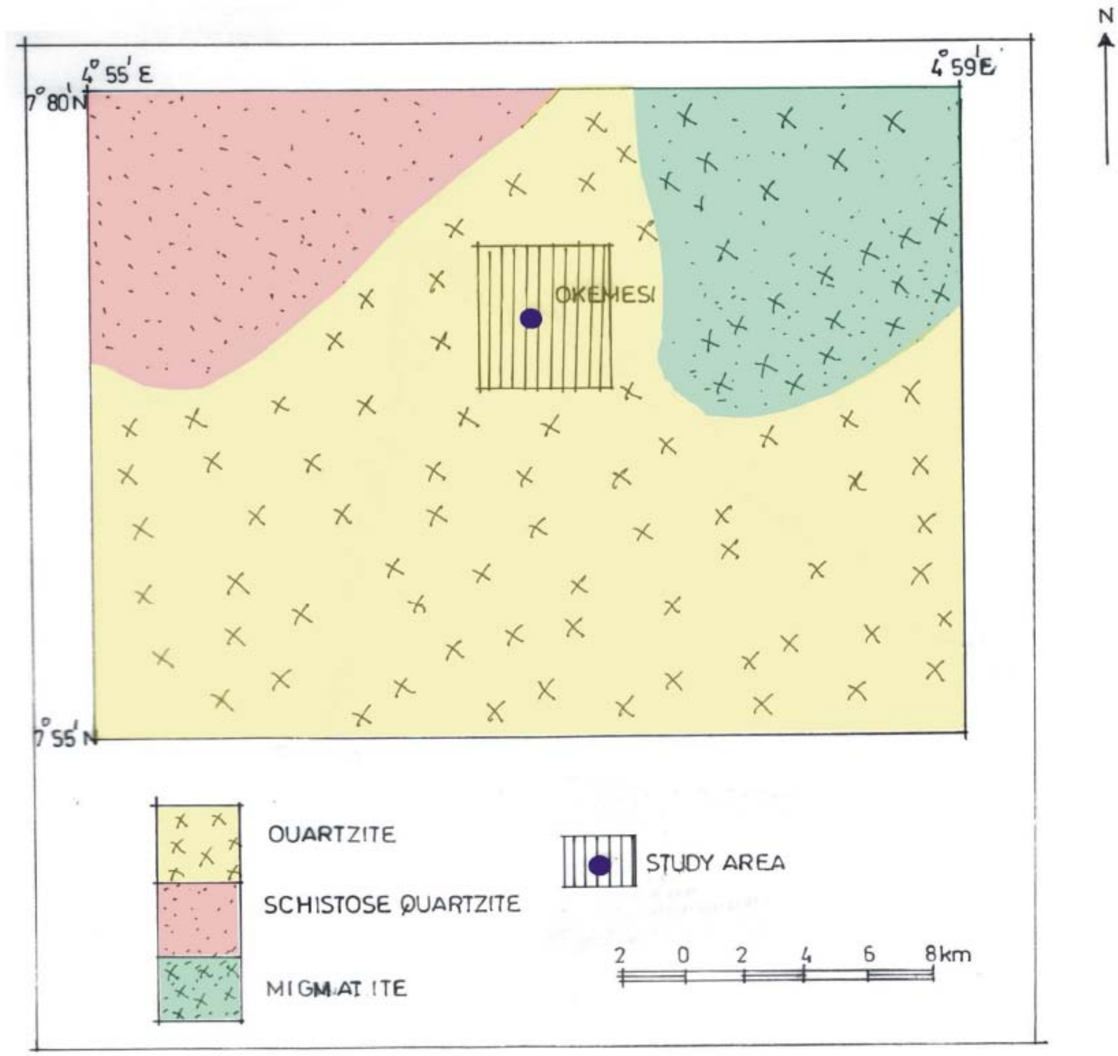

Fig. 4 : Geologic map of Okemesi Ekiti

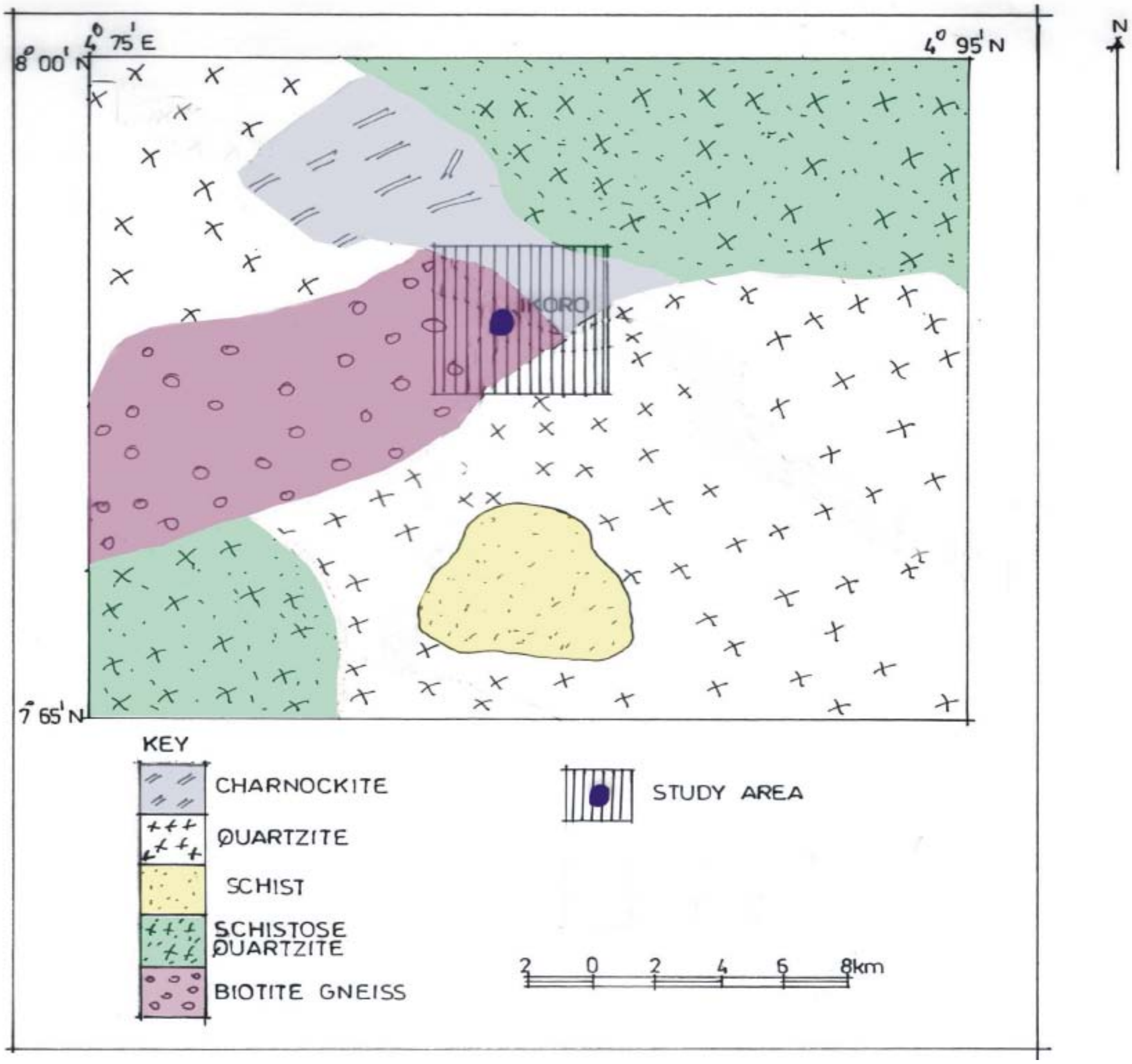

Fig. 5 : Geologic map of Ikoro Ekiti

V. Hydrogeological Setting of the Area

The availability of groundwater in the study area depends on the presence of decomposed material usually called overburden, which possesses a significant thickness and lateral extent to serve as reservoir. However, the quantity of water that can be accommodated under the subsurface depends also on the degree of porosity and permeability of the subsurface strata, it is a measure of the openings in which groundwater can exist. Although, basement rocks look solid to the naked eye but a microscopic examination reveals the existence of openings in the rocks. Following the instituted weathered profiles developed in the study area, the major soil types found there include alluvial soil, lateritic soil, sandy soil and clayey soil (Fig.6). The lateritic soils are highly weathered sub-soil that contains iron and aluminium. It ranges from soft, earthy, porous soil to hard dense rocks. The alluvial soil gives a record of high water level, the sandy soil in the area also forms a good and prolific aquifer, and the occurrence of clayey soil is not very prominent in the area under investigation.

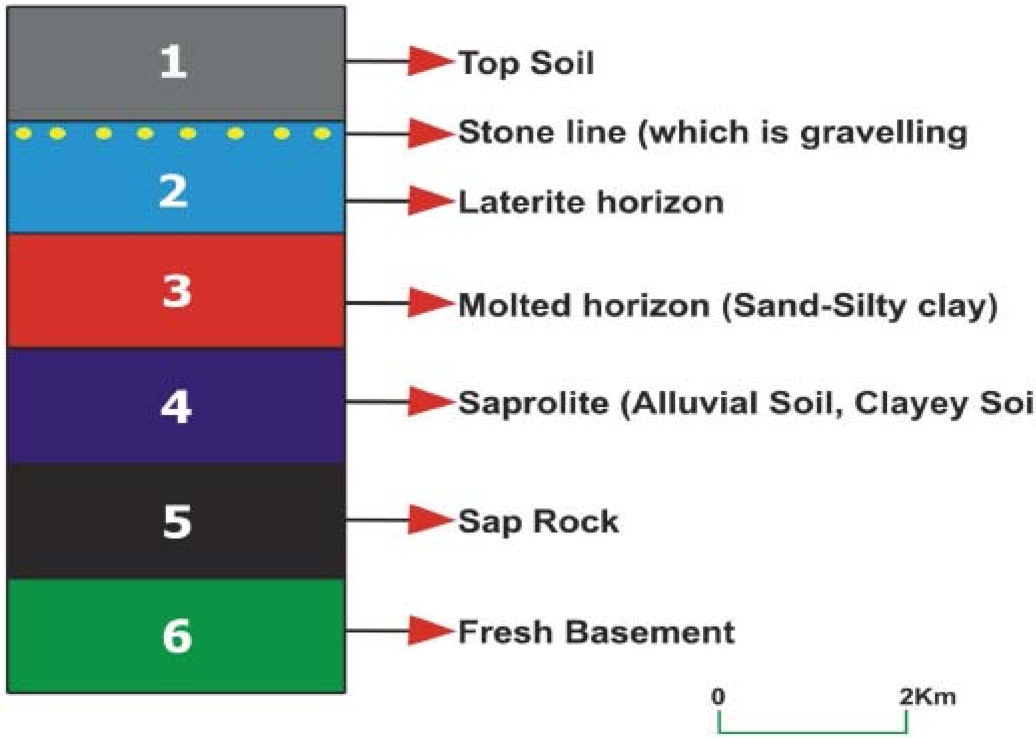

Fig. 6 : Weathering profile in the study area

The hydrogeological characteristic of the area under study is that the weathered products of the basement rocks often form a significant water-bearing layer directly overlying the fresh basement rocks as regoliths. Therefore, the process of rock weathering enhances the development and accumulation of groundwater in that the regoliths facilitates the ingress of water into the overburden and so transforms the ordinarily impermeable and impervious granites and gneisses into sources of abundant groundwater reserves and as such, water supply are exploited in this weathering profile through shallow hand-dug wells and boreholes by inhabitants. Metamorphic deformation and tectonism that occurred in these areas as well as the developed structural features are favourable to groundwater development and accumulation as confirmed by field observations.

VI. Method of Study

Fifteen (15) water samples were collected randomly from hand dug wells and boreholes within Ikoro and Okemesi Ekiti. The GPS was used to determine the geographic positions of these wells. Five (5) borehole water samples and four (4) hand dug well water samples from Okemesi and One (1) borehole water sample, five (5) hand dug well water from Ikoro were collected into clean and well drained sample bottles and were carefully labelled for each location. The water samples were collected early in the morning in order to allow suspended mineral matter to have settled down. The fifteen (15) samples were taken to the Federal Ministry of water resources, Regional Water Laboratory, Alagbaka, Akure, Ondo State for physio-chemical and bacteriological analysis.

VII. Results

The results of the physical characteristics of the wells and boreholes in the study area are presented in tables 1 and 2, while those of the chemical characteristics are presented in tables 3, 4, 5, 6, 7 and 8 respectively.

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Table 1 : Physical Characteristics of The Wells And Boreholes In Okemesi Ekiti

S/N	Location	Type of Well	Depth (M)	Lithology	Temp (°C)	Appearance	Colour (Hazen Unit)
2	Chief Odofin's house	BH	16.15	Quartzite	26.7	Clear	<10
3	St. Michael Anglican Church	BH	15.24	Quartzite	27.7	Clear	<10
4	Aafin Owa Ooye Okemesi	BH	17.68	Schistose quartzite	27.6	Clear	<10
5	Iro quarters	BH	18.29	Quartzite	27.3	Clear	<10
6	Oke Onire St (Ile Richard)	BH	21.34	Massive quartzite	27.0	Clear	<10
7	Oke Onire st	HDW	14.51	Quartzite	26.7	Clear	<10
8	Oke Onire st	HDW	12.62	Quartzite	27.1	Clear	<10
9	Oke Onire st	HDW	11.36	Quartzite	27.7	Clear	<10
10	Ile Obanla	HDW	12.62	Schistose quartzite	27.4	Clear	<10

Table 2 : Physical Characteristics Of Boreholes And Wells In Ikoro Ekiti.

S/N	LOCATION	TYPE OF WELL	DEPTH (M)	LITHOLOGY	TEMP (°C)	APPEARANCE	COLOUR
1	Opposite Magistrate Court	BH	17.07	Biotite Gneiss	27.3	Clear	<10
2	Odo Ojobe St	HDW	7.57	Biotite Gneiss	27.2	Clear	<10
3	Omoleye St	HDW	8.20	Quartzite	27.3	Clear	<10
4	Oke Iwaro St	HDW	11.36	Schistose Quartzite	27.0	Clear	<10
5	Idiolowo St (Palace Junction)	HDW	10. 72	Schistose Quartzite	27.0	Clear	<10
6	Oke Mesi	HDW	8.83	Quartzite	27.1	Clear	<10

Note : Bh- Boreholes
Hdw- Hand Dug Wells

Table 3 : Result Of Chemical Characteristics of Water In Okemesi Ekiti

Parameters	Sample 2	3	4	5	6	7	8	9	10
PH	5.97	6.87	6.82	6.66	6.23	6.52	5.96	6.43	6.64
Turbidity(NTU)	0.35	0.00	0.42	0.00	0.17	0.27	0.75	3.99	9.35
Conductivity(µs/cm)	1000	250	600	860	80.0	270	150	210	530
T.D.S (mg/l)	670	168	402	576	53.6	181	101	141	355
Total hardness	188	90.0	150	328	28.0	70.0	52.0	80.0	130
Calcium hardness	122	54.0	104	102	16.0	32.0	26.0	60.0	96.0
Magnesium hardness	66.0	36.0	46.0	226	12.0	38.0	26.0	20.0	34.0
Nitrate (NO_3) mg/L	0.98	1.32	ND	ND	ND	ND	ND	ND	11.3
Iron (mg/L)	0.35	ND	0.65	0.43	0.52	ND	0.49	0.27	0.38
Alkalinity	22.0	14.0	8.00	42.0	6.0	10.0	6.0	14.0	26.0
Manganese (Mn)	0.018	ND	ND	0.009	ND	ND	0.008	0.023	0.014
Calcium (Ca^{2+})	48.9	21.6	41.7	40.9	6.41	12.8	10.4	24.0	38.5
(Mg^{2+})	16.1	8.78	11.2	55.1	2.92	9.27	6.34	4.88	8.29
(Cl^{-})	124	28.9	81.9	79.9	5.99	26.9	10.9	10.9	35.9
Sodium (Na)	80.6	18.8	53.2	51.9	3.89	17.5	7.08	7.08	23.3
Bicarbonate (HCO_3)	22.0	14.0	8.00	42.0	6.0	10.0	6.0	14.0	26.0

Table 4 : Result of Chemical Characteristics Of Water In Ikoro Ekiti

Parameters	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Ph	7.74	7.00	6.70	6.97	7.50	6.82
Turbidity (NTU)	0.00	0.47	0.70	0.00	0.34	0.03
Conductivity (µs/cm)	760	930	1210	1070	1680	1350
TDS (mg/l)	509	623	811	717	1126	905
Total hardness (mg/l)	152	236	300	318	414	346
Calcium hardness	108	172	154	190	232	254
Mg hardness (mg/l)	44.0	64.0	146	128	182	92.0
NO_3 (mg/l)	30.8	18.3	11.2	9.7	5.4	ND
Fe (mg/l)	0.57	0.48	ND	0.67	0.33	0.45
Alkalinity (mg/l)	96.0	104	68.0	180	126	78.0
Manganese (mg/l)	0.018	0.010	ND	0.015	0.011	0.015
Magnesium (mg/l)	10.7	15.6	35.6	46.4	56.6	22.4
Chloride (mg/l)	38.9	86.0	131	86.0	210	152
Sodium (mg/l)	52.3	55.9	85.2	55.9	137	98.8
Bicarbonate (mg/l)	96.0	104	68.0	180	126	78.0
Suspended solids (mg/l)	251	307	399	353	554	445
Calcium (mg/l)	43.3	68.9	61.7	76.2	93.0	102

Table 5 : Summary Of Physico- Chemical Characteristics And Who's Standard For Drinking Water

S/N	Parameters	Range		Mean values		WHO, 1993 standards	
		Okemesi	Ikoro	Okemesi	Ikoro	Highest desirable	Maximum permissible
1	PH	5.96-6.87	6.7-7.74	6.46	7.12	7.0-8.9	6.5-9.5
2	Temperature °C	26.7-27.7	27.0-27.3	27.24	27.16	-	-
3	Conductivity(µs/cm)	80-1000	760-1680	438.9	1166.7	900	1200
4	Appearance	C	C	C	C	C	C
5	Turbidity	0-9.35	0-0.70	1.7	0.37	5.0NTU	5.0NTU
6	TDS (mg/l)	53.6-670	509-1126	294.18	781.83	500mg/l	1500 mg/l
7	Total hardness	28-328	152-414	124	29.33	100 mg/l	500 mg/l
8	Alkalinity	6-42.0	68.0-126	16.44	96.67	100 mg/l	100 mg/l
9	Calcium	16-122	108-254	680	185.0	NS	NS
10	Magnesium	12.0-226	44-182	56.0	109.33	20 mg/l	20 mg/l
11	Chloride	5.99-124	38.9-210	45.03	117.32	200 mg/l	250 mg/l
12	Nitrate	0.98-11.3	5.4-30.8	1.51	12.57	0.2 mg/l	3 mg/l
13	Iron	0.27-0.65	0.33-0.67	0.34	0.42	1 mg/l	3 mg/l

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14	Sodium	3.89-80.6	52.3-137	29.26	80.85	200 mg/l	200 mg/l
15	Manganese	0.008-0.023	0.010-0.018	0.008	0.012	0.1 mg/l	0.4 mg/l
16	Bicarbonate	6-42.0	68.0-126	16.44	96.67	-	-

Table. 6 : Correlation Coefficients Of The Physio-Chemical Parameters

Localities	Parameters	Correlation Coeeficient (R)	Remarks
Okemesi Ekiti	Between Total Hardness & Alkalinity	0.89	Positive correlation
	Between PH & Alkalinity	0.23	Positive correlation
	Between TDS & PH	0.03	Positive correlation
	Between TDS & Alkalinity	0.72	Positive correlation
Ikoro Ekiti	Between Total Hardness & Alkalinity	1.0	Positive correlation
	Between PH & Alkalinity	0.0023	Positive correlation
	Between TDS & PH	-0.13	Negative correlation
	Between TDS & Alkalinity	0.0023	Positive correlation

Table 7 : Result of Bacteriological Characteristics Of Water In Ikoro Ekiti

Parameters (Cfu/100ml)	Sample 2	3	4	5	6	7
Total Bacteria Count	10	12	11	8	10	9
E-Coli	0	0	0	0	0	0

Table 8 : Result of Bacteriological Characteristics of Water in Okemesi Ekiti

Parameters (Cfu/100ml)	Sample 2	3	4	5	6	7	8	9	10
Total Bacteria Count	9	7	10	8	12	11	10	14	16
E-Coli	0	0	0	0	0	0	0	0	0

VIII. Discussion of Results

The results of the physical, chemical and bacteriological analyses has been presented in tables 1, 2, 4, 5, 6, 7 and 8 respectively and were compared with WHO (1993) standards (Table.5). The physical analysis of the water samples revealed that all the water samples are clear with its Hazen's unit less than 10, they have no taste and odour with respect to human senses. The lowest temperature which is 26.7°C was obtained from sample 2(BH) and 7(HDW) in Okemesi Ekiti while the highest temperature 27.7°C was obtained from sample 3(BH) and 9(HDW) in Okemesi. The temperature ranges from 26.7-27.7°C in Okemesi Ekiti and 27.0-27.3°C in Ikoro Ekiti. However, the World Health Organisation sets no guideline for temperature. The conductivity of the water samples vary from 80.0-1680μs/cm (Table 6). The highest value for conductivity is found in Ikoro sample 5 while the lowest is found in Okemesi sample 6. All the samples tested has a conductivity value which range between the highest desirable and maximum permissible limit of WHO except Ikoro samples 5 and 6 whose values are higher having 1,680 and 1,350μs/cm respectively . The total dissolved solids concentration for the tested water samples vary from 53.6-1126mg/l which fell under the fresh water classification except Ikoro sample 5 which has a greater value of 1126mg/l and are classified under moderately saline water (Hem, 1970). With respect to the World Health Organisation for drinking water, all the tested samples fell within the highest desirable and maximum permissible limit which is (500-1500)mg/l respectively (Table.5). The average results of turbidity carried out on the water samples showed that all the samples fell within the highest desirable limit of World Health Organisation (WHO) standard for drinking water except Okemesi sample 10 whose value 9.35NTU is higher than the maximum permissible limit of WHO's standard (Table.5). The results of the chemical tests also showed that the pH value of water sampled ranges from 5.96-7.74 which indicated that the samples are slightly acidic to slightly alkaline, and the values conformed with WHO recommended standards for drinking water which is 6.5-9.5. The alkalinity of water sampled ranges between 6.0-126.0mg/l which also fell below the highest desirable limit of WHO except samples 2,4and 5 (Ikoro) which has a greater value of 104mg/l, 108mg/l and 126mg/l respectively. Hem (1970) classified water based on its hardness as follows;

Hardness (mg/l $CaCO_3$)	Range
Soft	0-60
Moderate	61-120
Hard	121-180
Very hard	>180

The total hardness of water samples ranged between 28-414mg/l which indicates great variation in hardness of tested water samples. Samples 6&8 (Okemesi) having a value of 28.0mg/l and 52.0mg/l respectively are soft; samples 3, 7, 9 (Okemesi) are moderate; samples 4 & 10 (Okemesi) and sample

1(Ikoro) are hard; samples 2 & 5(Okemesi) and samples 2, 3, 4, 5 & 6 (Ikoro) are very hard. All the water samples tested has a value of total hardness that fell within acceptable limits of WHO (100-500)mg/l. Also, the value of nitrate in some of the water samples range between 0.98-30.8mg/l which exceeded the highest desirable limits of WHO. The chloride concentration in the water samples range between 5.99-210mg/l which is below the maximum permissible limit of WHO which is 250mg/l. The range of Fe concentration in tested samples is (0.27-0.67)mg/l which is also below the desirable limits of WHO (1)mg/l. The concentration of sodium in tested water samples range between (3.89-137) mg/l which is below the highest desirable limits of WHO (200)mg/l .

The summary of the various physical and chemical parameters, their mean values compared with WHO standards for drinking water is shown in Table 5. Virtually, all the mean values of parameters tested for in the water samples from Ikoro Ekiti are higher than that of Okemesi Ekiti except in the case of temperature, turbidity and total bacteria count (Table .5). The variation in progression as one parameter relates to the other is shown in figs 7, 8, 9, 10, 11 and 12. There is a great variation as PH, TDS and Alkalinity relates one with another as shown on the graphs. The overall mean of the turbidity value for Ikoro samples is 0.37NTU while that of Okemesi is 1.7NTU (Table.5) and the recommended value for turbidity by World Health Organisation is 5.0NTU both at highest desirable limit and maximum permissible level. Thus, from this comparison, it can be conveniently said that the water samples from Ikoro and Okemesi Ekiti are less turbid. All the parameters (PH, Alkalinity, TDS, Total Hardness) are positively correlated except TDS and PH for Ikoro samples which is negatively correlated (Table.6).

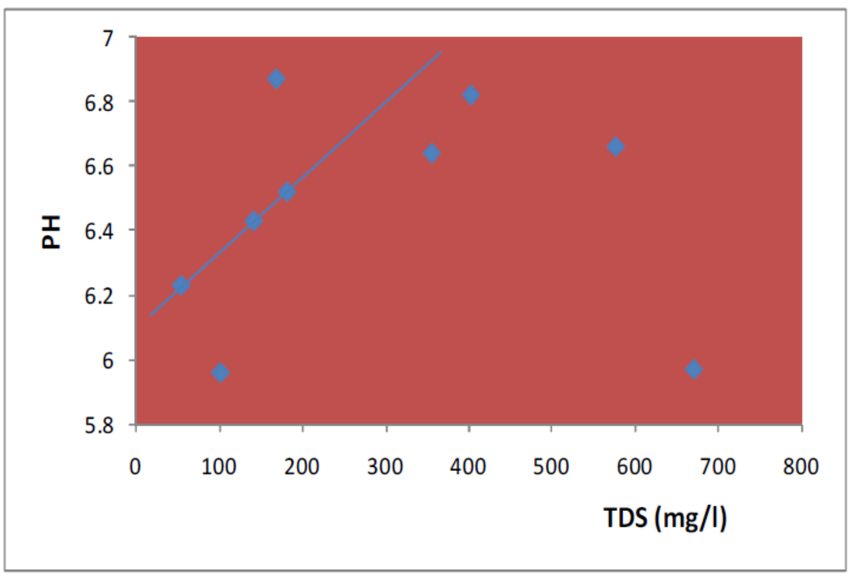

Fig 7 : Graph of PH against TDS for Okemesi samples.

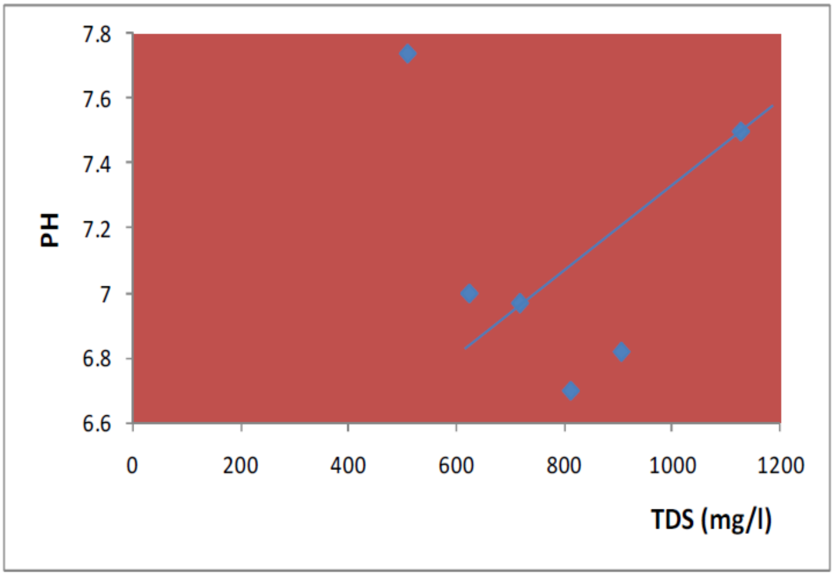

Fig .8 : Graph of PH against TDS for Ikoro samples

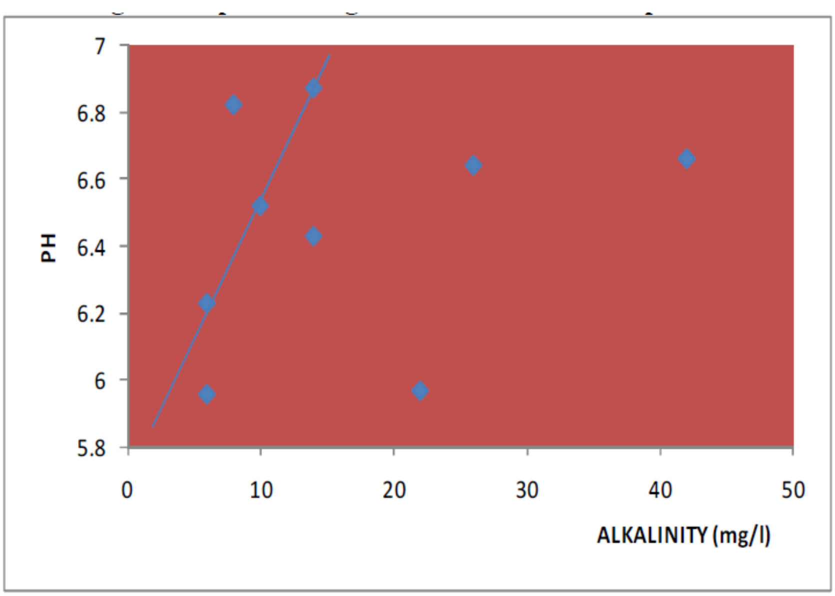

Fig. 9 : Graph of PH against Alkalinity for Okemesi samples

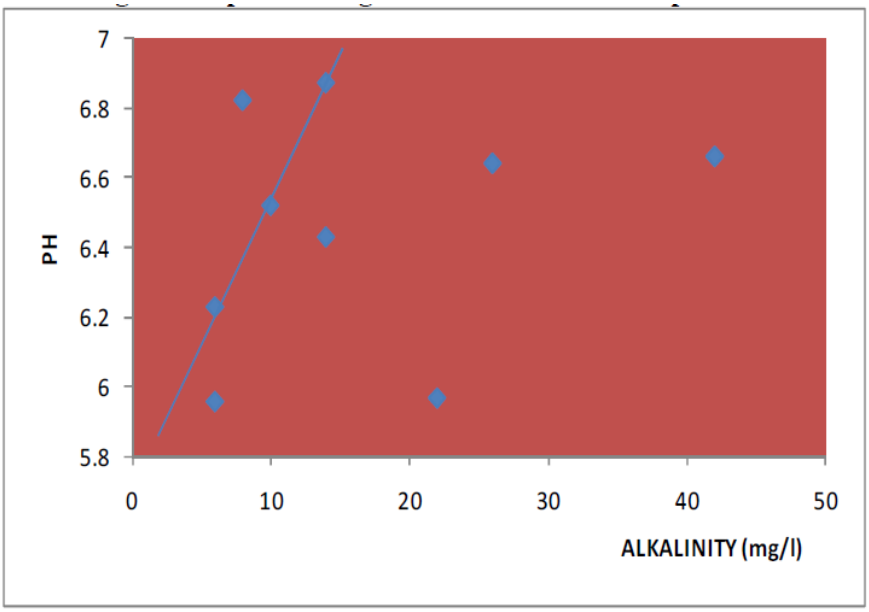

Fig. 10 : Graph of PH against Alkalinity for Ikoro samples

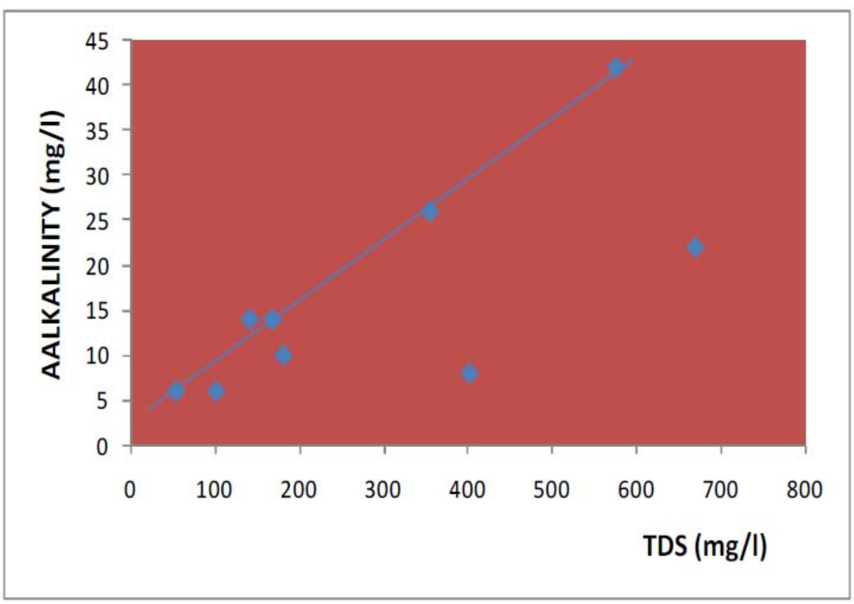

Fig. 11 : Graph of Alkalinity against TDS for Okemesi samples

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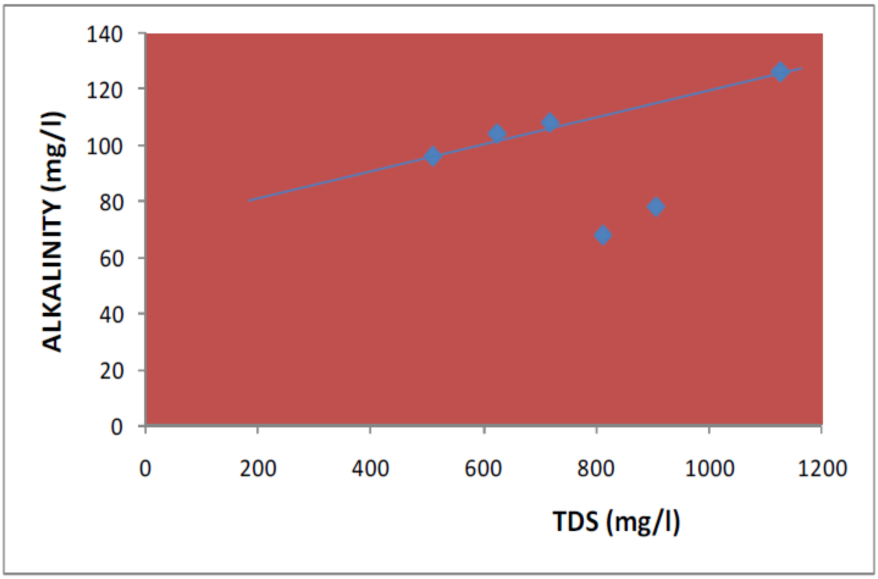

Fig. 12 : Graph of Alkalinity against TDS for Ikoro samples

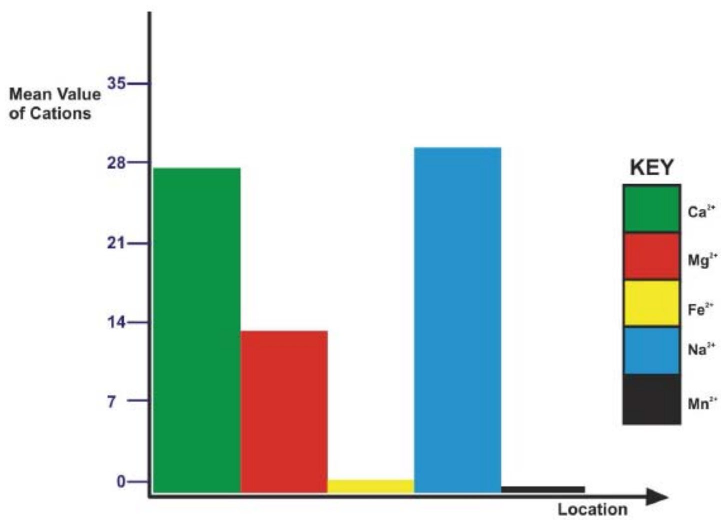

Fig. 13 : Histogram of mean concentration of cations for Okemesi

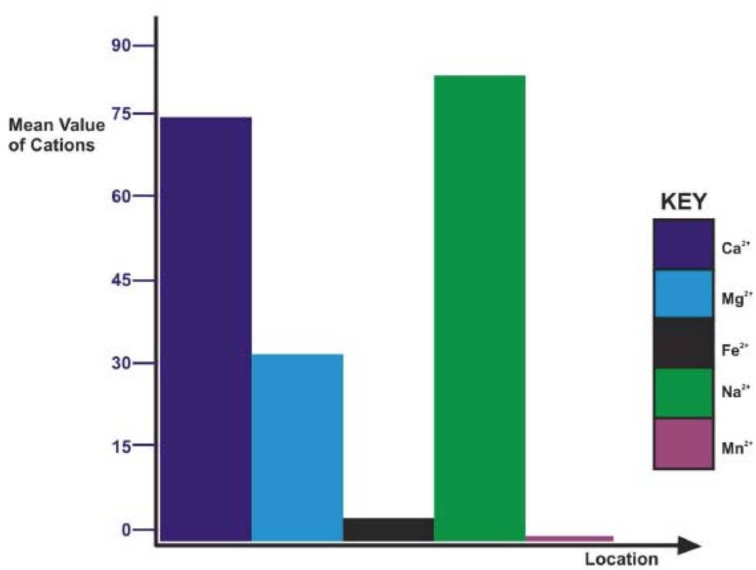

Fig. 14 : Histogram of mean concentration of cations for Ikoro samples

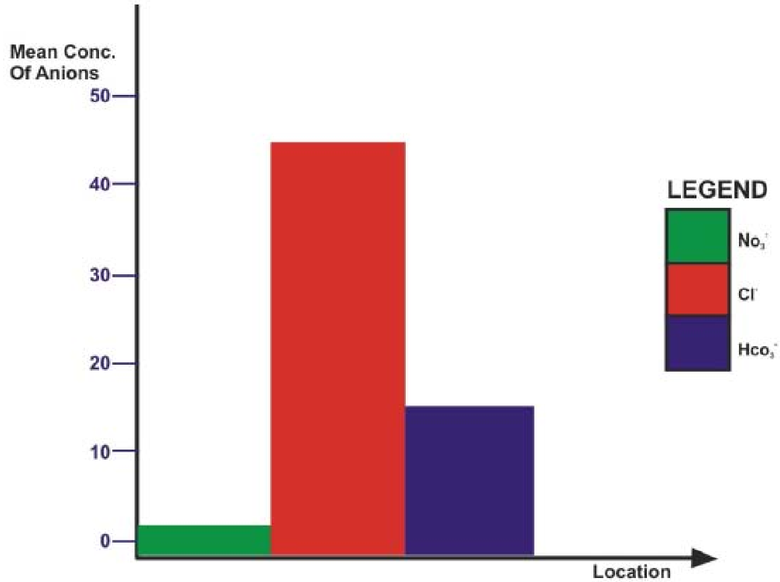

Fig.15 : Histogram of mean concentration of anions in Okemesi

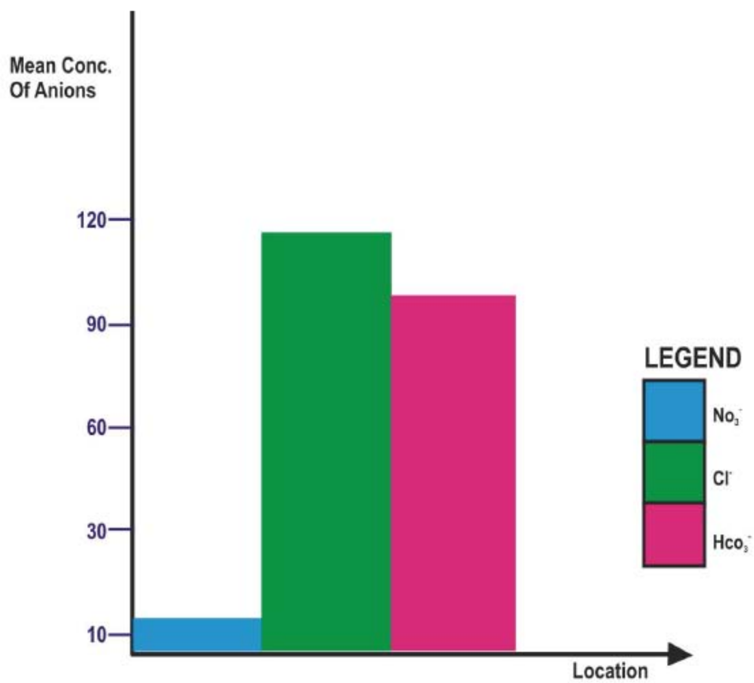

Fig.16 : Histogram of mean concentration of anions in Ikoro

The total bacterial counts for the analysed water samples from the study area range between 7Cfu/100ml-16Cfu/100ml (Tables 7&8), this shows a relatively high load of bacteria in the water as no sample should contain more than 3 coliform per 100ml as stipulated by World Health Organisation. The results of analysis shows that the total bacteria counts in Okemesi water samples range from 8Cfu/100ml-12Cfu/100ml and that of Ikoro Ekiti ranges from 7Cfu/100ml-16Cfu/100ml with the overall mean of 10.78Cfu/100ml respectively. All the water samples analysed from both Ikoro and Okemesi has zero value for E-Coli which is acceptable as World Health Organisation states that no sample should contain E-Coli in 100ml. Coliform organisms should not be detectable in 100ml water sample. However, the quality of water is strictly based on some physical, chemical and bacteriological parameters. Some of these parameters are inherent in surface water and their sources are mainly from precipitation, leaching of soil particles during infiltration, decay of organic matter, salt water intrusion, exchange of ions with surrounding rocks and human activities etc. Continuous occurrence of these processes lead to the increase in concentration and values of the parameters which in turn influence water quality. According to WHO (1993) standard for drinking water, the maximum allowable range for pH of water is 6.5-9.2 and the result obtained from analysis showed that the pH of all the water sampled at Ikoro-Ekiti are within acceptable limit, but in the case of water sampled at Okemesi, Sample 2, 6,8,9 has pH less than the WHO's limit. This low pH may be due to the presence of some contaminants such as ammonia that can furnish hydrogen ion in water (e.g. ions of iron). It might be due to dissolved carbon dioxide absorbed from air or released into the water as a result of bacteria activities. According to the result obtained, the wells and borehole investigated appeared to have uniform temperature which range between 26.7°C - 27.7°C and this is a typical characteristic of groundwater temperature, the uniformity in groundwater temperature is advantageous for water supply. The physical parameters such as colour, temperature, conductivity, pH, TDS and total hardness of water in the study area are satisfactory for drinking water. Except for the turbidity of Okemesi sample 10 whose value 9.35NTU exceeds that of WHO standard of 5.0NTU.Water become turbid when substances like silt, clay, colloidal and organic matter are present. This especially happens to surface water during rainy season. The chemical parameters of water are its anion and cation concentrations (table 5 and figs 13, 14, 15 and 16). The concentration of magnesium in most of the water sampled exceeded the highest desirable value as stipulated by WHO. Chloride concentration is very low compared with that of the WHO standard for drinking water (250)mg/l. Although, the chloride concentration in sample 5 (Ikoro) has a high value compared with other samples, the highest value for water hardness is found in sample 5 and 6 (Ikoro) and this is as a result of the high concentration of calcium and magnesium ions that dissolves in the water samples. The water hardness results obtained are permissible because the values are below the maximum permissible concentration for water hardness which is 500mg/l. The nitrate concentration is relatively high when compared with WHO standard for drinking water. High concentration of nitrate results in the death of young infants as a result of metahaemoglobinaemia or blue baby disease. Since the gastric juice of young infants lack acidity, nitrate-reducing bacteria can grow in their upper intestinal tracts. When nitrate is ingested, it can be reduced to nitrite before the nitrate is completely absorbed in the bloodstream and combine with haemoglobin to form metaheamoglobinaemia, which is ineffective as oxygen carrier. This produces anoxenia which can lead to the death of infants by asphyxia. Older infants and adults can tolerate higher level because their stomach's PH is too low for nitrate reducing bacteria. However, nitrate reducing bacteria leads to the production of nitrosamines in the stomach. The sodium concentration in sampled water varies uniformly and its concentration is below the highest desirable limit recommended for drinking water by World Health Organisation.

There are variations in the results obtained for total dissolved solids of the water samples and this may be due to high concentration of calcium and magnesium ions and probably the aquifer of these samples contain clay minerals which consequently dissolve solids. The World Health Organisation recommended that the number of bacteria and coliform count should be zero per colony. The result obtained from the microbial test (Tables 7&8) showed that the total number of bacterial count found in all the water samples are numerous and are above the WHO standard whereas the E-Coli have a zero value for all tested samples. The bacteria might have originated as a result of faecal contamination in the water by human beings and animals or they could have been deposited in sediments and now migrated into the water. Therefore, it will be advised that the water in the areas be boiled properly before consumption or use other methods of purification to make it potable so as to prevent the outbreak of diseases. The presence of these bacteria in water results in disease like diarrhoea, cholera, typhoid, infections, hepatitis, giardiasis, amoebiasis and dracunuliasis; if there is continuous consumption of the water from the study areas. (Adapted from Bradley, D.J London school of Hygiene and Tropical Medicine).

IX. Conclusion

A comparison of results of the physiochemical and bacteriological analysis of the water samples collected from the study areas and the WHO international standard on potable water revealed that the water in the study area has no permanent chemically induced colour, they are tasteless, odourless and are slightly acidic to slightly alkaline. The low total dissolved solids (TDS) revealed the water to be from a fresh water source. The chloride and nitrate gives an indication of faecal pollution in the water, this is reflected in the bacteriological analysis employed which showed that the water in the study area is contaminated with faecal coliform. It is suggested that the high load of bacteria in the water might have originated from plant debris, animal and human excretal, legumes and the atmosphere. The high bacteria count indicates very heavy pollution which is beyond the limit of the World Health Organisation bacteriological standard for drinking water. This is unacceptable and not recommended as potable water unless special treatments and designs are adopted. It can be concluded that the water chemistry has been found to be dependent on the chemistry of the basement rock, leaching during infiltration, exchange of ion with the reservoir rock, human activities and effluent, discharge from rivers. Also, it was observed that not only the geology, topography, weather (climate) and rock influence water chemistry but man himself has a very strong influence. Therefore, it can be concluded that the entire water sample analysed met the requirements for good water supply with minimum scientific treatment.

X. Recommendation

It has been observed from this study that hand dug wells and boreholes based on chemical and bacteriological analysis result is potable for public water use such as drinking, cooking and other domestic purposes. Also, majority of these wells can serve as a means of transporting diseases into human body. Therefore, the following recommendations are hereby made from the outcome of the research:

1. Wells constructed should be properly ringed and covered to avoid the washing of surface particles into the wells during rainy seasons.
2. The wells should be treated with chlorine and alum from time to time to keep the water fit for human consumption. Water from the wells and boreholes should be boiled before drinking.
3. Government should set up a board to enforce the cleanliness of well environment to ensure the portability of the water supply.
4. The hydrogeological mapping and groundwater quality of the area should be reinvestigated thoroughly, at least for a minimum period of two years so as to improve on this work.
5. Stream passing through a well location should be prevented from polluting or contaminating such well.
6. There should be proper disposal of industrial and household waste.

Since men cannot survive without water, it is very necessary that water wells and boreholes in our communities be purified to meet the agreement with the World Health Organisation requirement.

XI. Aknowledgement

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