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Physical, Chemical and Bacterial Analyses of Groundwater in Ikere Township, Southwestern Nigeria

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ABSTRACT

Groundwater in Ikere Township in Ikere Local Government Area of Ekiti State, Nigeria was assessed for its physical, chemical and bacterial components. Water from 12 wells whose depths varies from 9 m-21 m was analyzed. The pH, conductivity, total dissolved solids and temperature of the groundwater conform to the World Health Organization (WHO) standards for potable water. Metals and compounds which include Magnesium, Calcium, Nitrite, Sulphates, Nitrates, Chlorides, Iron and Phosphates are concentrated in the groundwater to levels which are not injurious to human health if consumed, when compared with the standards set by the World Health Organization for safe and potable water. However all samples of groundwater examined contain bacteria especially, *Escherichia coli* and *Coliforms* which makes the water unsafe if consumed untreated. These organisms can be removed from the groundwater through chlorination, boiling and filtering before consumption.

Keywords: *Hydrogeology, Potability, Aquifer, Coliform, Escherichia coli, W.H.O.*

1. INTRODUCTION

Ikere-Ekiti lies within the Precambrian crystalline basement complex of southwestern Nigeria. Information on the hydrogeology of the basement complex southwestern Nigeria is scanty in literatures. One of the few works on the hydrogeology of the southwestern Nigeria [1] who described on the basis of remote sensing interpretation, fractures which controls ground water accumulation in southwestern Nigeria especially at Ojirami dam in Igarra. [2] concluded that the quality of an aquifer is a function of the geological setting of the area, hence the difference between the characteristics of aquifers in the basement complex and sedimentary environments. Although it is reasonable that water may accumulate in fractured basement rocks, hand dug wells have been positioned in the weathered overburden soil because of economic implication on the individuals and the communities in general.

Groundwater, though mostly originates from rain or snowmelt infiltrates through soils into subsurface aquifers, is apparently purer than surface water because of the natural purification process which it undergoes while percolating through piles of soils. Uncontaminated groundwater is naturally clear, tasteless and odorless. According to Davis and De wiest [3], drinking water 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, according to [4], the water cycle is an obvious mode of transmission of enteric diseases. However human activities especially production and disposal of industrial wastes and sewage systems alter and pollute the natural pure state of groundwater. If contaminated groundwater is therefore supplied to a community where people live untreated, the inhabitants of such community may be infected by water borne diseases which might reach an epidemic scale. Water-related diseases include those due to micro-organisms and chemicals in water people drink; diseases like schistosomiasis which have their lifecycle in water; diseases like malaria with water-related vectors; drowning and some injuries; and others such as legionellosis carried by aerosols containing certain micro-organisms. More people have safe drinking water, but not many have access to toilets. The world is on track to achieve the MDG target on free access to potable water. Water generally is an indispensable substance for survival and growth of any living organism [5]. It should therefore be of primary concern for any government to provide potable water free from harmful micro-organisms and undesirable chemicals [6]. Untreated drinking water could be a potential medium for transmitting infectious diseases [7]. Therefore the chemical and bacteriological assessment of potable water should be given an uttermost attention. In Nigeria the supply of treated water for consumption has remained a recurring problem [8]. Attention has to turn to tapping the groundwater in many communities by sinking wells.

According to [9], over 385,000 children die annually of various diseases due to drinking contaminated water. In Nigeria, the death toll from water-borne diseases is not restricted to children alone. We have had epidemic cases of cholera killing both young and old due to drinking unhygienic water in the past. Isolated cases of cholera outbreak are reported periodically in the national dailies in Nigeria. Polluted water is

potentially dangerous to health because of possible outbreaks of typical dysentery or cholera, epidemics and other water-borne diseases. However, the chemistry of rocks and soils and the rock geological condition in any area has a great influence on the quality of water, which determines the concentration of introduced cations and anions in the water, making it unsuitable for the consumption [10]. A lot of studies abound in the literature on water quality assessment and development and also on heavy metal pollution on water sources. Such works include [11; 12; 13] . All concluded that there was the need to monitor water quality on regular basis. This is because the increase in concentration of trace elements in potable water, microbial contamination from faecal *coliform* and E-coli and influence of filths, unguided wastes and sewage disposal will increase the threat to man's health and life. Cases of diarrhea affecting both children and adults are commonly reported in our hospitals especially in the rural area where potable water is not available and untreated ground well water serves as one of the major sources of domestic water supply.

All over the world there is an increasing demand of potable water in industries or in variety of other uses. And surface water resources cannot adequately satisfy this astronomical increasing demand for potable water in both developing and industrialized world. Groundwater resources have a major role to play in the provision of potable water for the world populace and industries now and in the future. Consequently, healthy living is a function of accessible potable water supply. In Ikere Township (Fig. 1), potable pipe borne water is a rare but essential commodity. Less than 2% of the 320,000 inhabitants in this local government area have access to the intermittently supplied pipe borne water. Most homes in the area depend on groundwater wells for their survival. However, since these wells sunk to tap the groundwater are situated in towns and villages where human beings dispose wastes, and animals like chicken, dogs and goats stray about and defecates arbitrarily, bacteria contents of the well water, were also investigated. There is no evidence that the groundwater wells in Ikere Township have been assessed scientifically. This paper therefore focuses attention on the physicochemical and bacterial assessments of water from selected groundwater wells in Ikere Township to determine the potability of the water. The experimental results from the study would be compared with the World Health Organization standards for potable water.

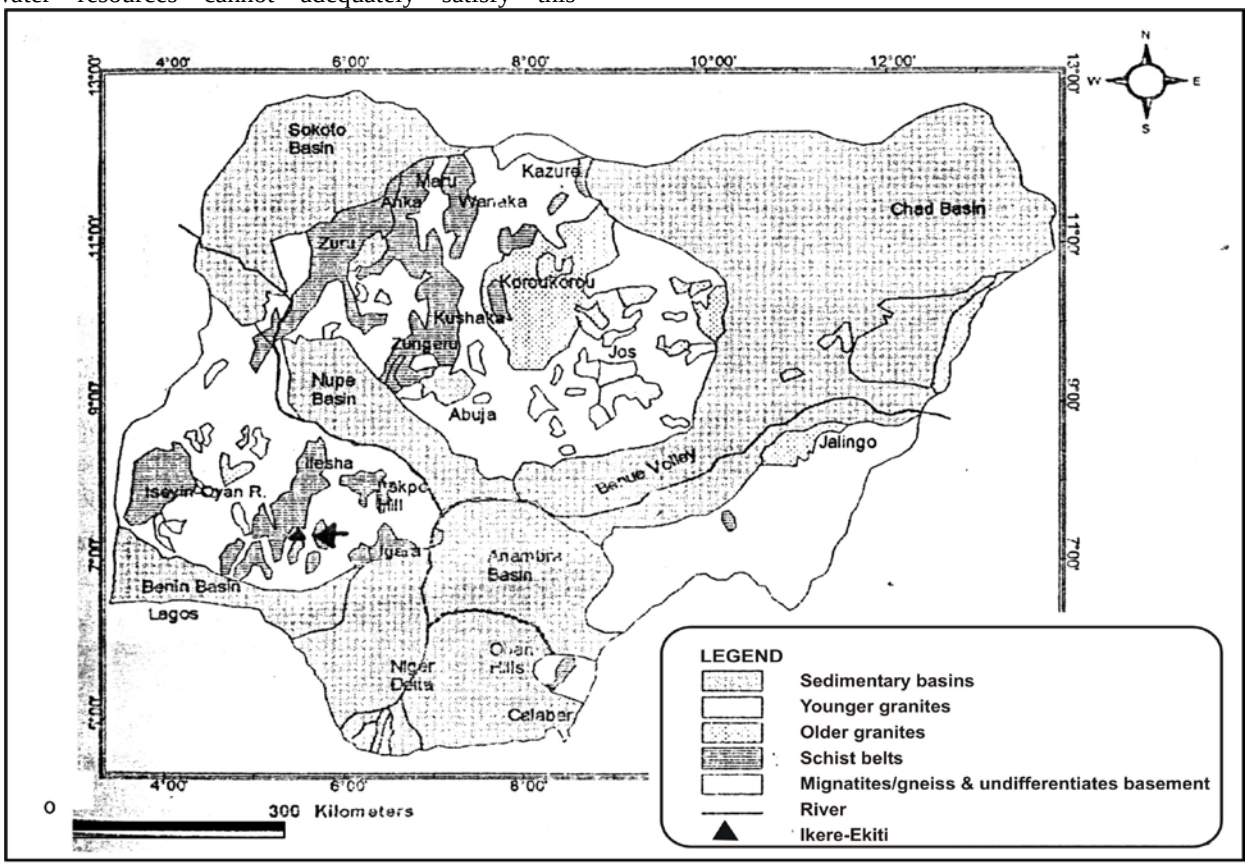

Fig. 1: Generalised geological map of Nigeria showing the Basement Complex Rocks, Schist Belt, the younger Granites, Sedimentary Basins and study area in a triangle (Modified from woakes et al., 1987)

2. GEOLOGICAL AND HYDROLOGICAL SETTING

The schist belts in southwestern and northwestern Nigeria are well exposed and have been well studied [14]. The schist belts are very critical to the understanding of the basement complex geology of Nigeria according to [15]. Two age generations have been proposed for the southwestern Nigerian schist belts : one is migmatite-gneiss complex sequence of Archaean to Early Proterozoic underlies Ikere township in Ikere Local government area (Fig. 1) while the other is Late Proterozoic as depicted by Older Granite [16]. Ikere Local Government lies within latitudes $6^{o}18^{1}$N and $6^{o}29^{1}$N and longitudes 5^{o} 20^{1}E and $5^{o}30^{1}$E (Fig. 1) in the equatorial rain forest with two distinct periods of rainy and dry seasons. The long rainy season begins in February and ends in November while there two or three rainfalls during the short dry season in December or January. The average annual the short dry season starts late in November/December and ends early in February. The main rainfall is between 1750mm-3500mm with temperatures ranging from 28^{o}C – 37^{o}C throughout the year. [17]. Ikere township area is part of the southwestern Nigeria basement complex which is composed of Precambrian rocks that have evolved through four major tectonic episodes. These crystalline rocks are folded, fractured, faulted and jointed thus creating secondary openings in these rocks; otherwise the rocks are neither permeable nor porous. Weathering of previously existing rocks is very pronounced and leads to breaking down of rock materials and deposition of lateritic soils which may be as thick as 8m-19m. These form overburden zones which are porous and permeable and thus form aquifers which house groundwater in Ikere town area. This area is drained by Ogbese River, River Osun and other numerous streams and drainage pattern that appear to follow fault lines in the basement complex.

3. MATERIALS AND METHODS

Well water samples were taken from twelve wells, stored in sterilized polythene bottles and covered after taking appropriate precautions to prevent contamination. The odor was recorded for each sample using human senses. Alkalinity, calcium, and magnesium hardness and other minerals (Ca, Mg, Na, K, Cl and Fe) concentrations in the groundwater samples were determined using a Buck Scientific Model 200A/B Atomic Absorption Spectrophotometer (AAS). Total bacteria count *Eschericha coli* and coli form colonies were determined using culturing in incubators at 37^{o}C for 24 hours. The temperature of the groundwater well samples was determined immediately after collection using a thermometer and Lovibond Comparator for the colour determination, while Conductivity Meter Bridge was used for turbidity measurement and pH meter used to determine the acidity of the water samples. Total dissolved solids were determined by evaporation, weighing 100 ml of water sample and then subtracting the weight of the residue from the weight of water before evaporation.

4. RESULTS AND DISCUSSION

Physical Measurement

About 94% of the well water sampled was odorless and colorless while 6% have unpleasant odor and are colored. The depth of the wells sampled varied from 9-21 m. The water samples from relatively shallow depth have varied temperatures from 26-28^{o}C, which is characteristic of groundwater at shallow depths. The wells which are deep have relatively uniform groundwater temperature of between 24.5^{o}C and 25^{o}C (Table 1). However none of the water samples has temperatures higher than 28^{o}C which is the maximum allowable standard by WHO for drinking water.

This means that based on standard temperature requirement, the groundwater at Ikere township area is potable. The pH values for groundwater here ranges from 6.85-7.58 which falls within WHO's maximum standards (Tables 1 and 4). The colour, conductivity and total dissolved solids in the groundwater in Ikere township area are within maximum acceptable and maximum allowable concentrations of WHO's standards for drinking water. This implies that based on physical parameters alone, the groundwater at Ikere Township is potable although filtration and chlorination might be required to remove the colour and the unpleasant odor from the wells whose water seems colored and smelling.

Table 1: Physical Parameters of Groundwater Wells in Ikere Township

Sample	Temp(^{o}C)	Ph (Hacum)	Colour	Turb (NTU)	Conduct (usem-1)	TDS (mgl^{-1})
W1	25.5	7.15	14.4	17	235	153
W2	24.4	7.42	04.0	7	760	418
W3	24.8	7.40	13.3	15	761	419

W4	26	6.85	8.7	13	769	243
W5	27	7.30	2.5	6	442	81
W6	25.9	7.47	8.6	100	124	199
W7	26.2	6.95	7.3	8.9	306	202
W8	27.4	8.38	7.3	10	377	150
W9	24.7	7.34	7.0	10	650	315
W10	24.5	7.60	10	10	794	450
W11	24.3	7.15	7.8	9	224	123
W12	25	7.15	8.0	11.5	661	240

TDS = Total Dissolved Solid, $Mg1^{-1}$= Milligram per litre. W = well

Chemical Characteristics

Of the 12 wells sampled, only well 2 (GW2) contains alkalinity which is a little above WHO's standard for drinking water. Here alkalinity value of 206 $mg1^{-1}$ was recorded whereas the maximum allowable contamination value by WHO is 200 $mg1^{-1}$. Other samples contained alkalinity values which conform to WHO standard for potable water (Table 2). Nitrite and nitrate concentration values were within the standards of WHO for drinking water (Tables 2 and 4).

Although chloride concentration varies in the 12 well samples, all fall within the maximum concentrations recommended by WHO for drinking water (Tables 2 and 4). SO_4^{2-}concentration values in Ikere township area groundwater varies from 0 to 30.1 $mg1^{-1}$.These concentration levels are still lower than the maximum concentration acceptable for drinking water by [9]. This implies that sulphate concentration in Ikere township groundwater cannot be a threat to human health if consumed. Six wells in the area of study contained no detectable level of PO_4^{3-}. Other samples contained tolerable concentrations when compared with WHO standards (Tables 2 and 4).

Total hardness of groundwater at Ikere township area varies from 67 mg/l to 300 mg/l which falls within the stipulated WHO limits of 500 mg/l for drinking water (Tables 2 and 4). Calcium hardness, magnesium hardness, (Ca and Mg) in all the water analysed were within the limits allowable by WHO standard for potable water. Na and K concentrations were within the ranges recommended by WHO for potable water (Tables 2 and 4). Fe was not detectable in 3 of the wells while the remaining nine wells contained Fe which was very low in concentration conforming to WHO standards. Considering the chemical data presented above, the Ikere township groundwater seemed ideal for human consumption.

Table 2: Chemical Data for Ground Well Water in Ikere Township Area (mgl^{-1})

Sample	Alkanity	NO_2^{-2}	NO_3^{-2}	Cl^-	SO_4^{2-}	PO_4^{3-}	Ca Hardness	Mg Hardness	Total Hardness	Na^+	K^+	Ca^{2+}	Mg^{2+}	Fe^{2+}
W1	52	0.02	0.06	18.0	1.8	0.05	66	11	77	10.5	4.9	26.5	2.7	0.12
W2	206	Nd	0.02	69.0	15.60	0.05	70	41	235	26.3	5.2	77.8	10.0	0.04
W3	176	0.02	0.02	60.5	15.60	Nd	50	44	198	26.3	7.5	61.7	10.7	0.08
W4	171	0.03	0.01	47.5	12.10	0.3	40	30	248	30.0	5.0	74.6	15.7	0.13
W5	55	0.03	Nd	27.0	3.50	Nd	35	29	131	78.0	37.5	32.9	10.1	0.10
W6	42	0.01	Nd	4.5	Nd	0.8	48	19	68	1.3	3.9	19.2	12.1	Nd
W7	93	0.01	0.07	17.5	3.50	Nd	90	39	122	9.3	7.0	36.1	4.8	Nd
W8	63	0.04	0.03	14.0	1.10	0.2	60	35	165	27.2	3.8	42.0	3.0	0.04
W9	84	0.01	0.06	14.7	10.2	0.6	50	10	115	15.6	5.2	20.6	10.2	0.01
W10	64	0.02	0.06	20.5	23.0	Nd	69	46	79	9.8	11.0	27.5	10.2	Nd
W11	144	0.04	0.04	15.5	20.8	0.6	19	40	302	8.5	6.8	37.9	17.4	0.01
W12	94	0.02	0.03	25.6	30.1	Nd	62	42	108	9.5	7.5	41.3	11.6	0.02

Symbols as in Table 1, Nd= not determinable. W = well.

Bacterialogical Analyses

Table 3 shows the average data of the bacteria counts for each well sample after analyses. *Coliform* counts ranges from 7 colonies to 45 in 12 wells examined. The count for Escherichia coli ranges from 2 to 22 in 12 wells while total bacteria counts vary from 11-69. From the above results it is obvious that the groundwater at Ikere Township contains microbiological organisms that can be very injurious to human beings and endanger general public health if consumed or used for domestic purposes without scientific treatment. According to [18], Ground water derived from deep wells are generally of good bacteriological quality because vertical percolation of the water through soil, results in the removal of much of the microbial and organic population, by contrast; waters from shallow wells are grossly polluted.

The abundance of E- Coli form bacterial therefore answers the question why diseases such as typhoid fever, paratyphoid, diarrhea attack, illness Sore attacks and other Skin diseases are common in the study areas. The World Health Organization requires that potable water should be free from dangerous micro-organism especially *Escherichia coli.* However this organism can easily be destroyed through chlorination and boiling. It is encouraging to report that the groundwater at Ikere Township is physically and chemically potable as discussed previously in this paper. The pollution caused by the presence of micro-organism can be remedied by filtering, chlorination and boiling. These physical processes if adopted will make the groundwater at Ikere Township completely safe for human consumption and use in industries.

Table 3: Microbiological Data for Ground Well Water from Ikere Township Area

Samples	Coli form	E.Coli	Total Bacterial
W1	24	11	12
W2	16	8	50
W3	45	21	61
W4	31	12	52
W5	13	11	32
W6	7	4	11
W7	13	8	26
W8	10	12	31
W9	18	9	28
W10	27	12	48
W11	45	22	69
W12	22	11	49

Escherichia coli

W = well

Table 4: WHO Standards for Drinking Water

Parameters	Minimum Concentration Acceptable ($Mg1^{-1}$)	Maximum Concentration ($Mg1^{-1}$)
Colour (Hazen)	5	50
Turbidity (NTU)	5	25
Ph	7.0 - 8.5	6.5 – 9.2
Total Dissolved Solid	500	1500
Total Hardness	10	500
Alkalinity	-	250

Chloride(Cl^{-1})	200	600
Calcium(Ca^{2+})	0.3	1.0
Magnesium (Mg^{2+})	50	150
Nitrate ($N0^{3-}$)	-	45
Nitrite ($N0^{2-}$)	-	1.0
Sodium(Na^{+})	-	200
Potassium(K^{+})	-	200
Phosphate	-	0.4
Temperature	-	28^{oC}

World Health Organization

Parameters ($Mg1^{-1}$)	Min. Conc.Acceptable	Max. Conc. Acceptable
Colour Hazen unit	5	50
Turbidity (NTU)	5	25
pH	7.0-8.5	6.5-9.2
Odour/Taste	-	-
Total Dissolved Solid	500	1500
Total Hardness	10	500
Alkalinity	-	250
Chloride ($C1^{-1}1$)	200	600
Iron (Fe)	-	-
Calcium (Ca^{2+})	0.3	1.0
Magnesium (Mg^{2+})	50	150
Nitrate (NO^{3-})		45
Nitrite (NO^{2-})		1.0
Sodium (Na^{+})		200
Potassium (K^{+})		200
Phosphate		0.4
Temperature		$28^{o}C$

5. CONCLUSION

The results of the physical and chemical parameters used to access the groundwater in Ikere township area revealed that it is safe for human consumption. Calcium, Magnesium, Iron, Chlorides, Nitrates, Nitrites and Phosphates concentrations in the groundwater at Ikere township area are within the levels recommended by World Health Organization for potable water. However, the groundwater contains *Coliforms* and *Escherchia coli* which render it unsafe to be consumed raw. The groundwater can be made completely potable by scientific treatment that is filtration, chlorination and boiling.

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