ASSESSMENT OF GROUNDWATER CONTAMINATION OF HAND DUG WELLS IN IPELE, ONDO STATE, NIGERIA

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ABSTRACT

The physical, chemical and bacteriological quality of traditional hand dug wells in Ipele, Ondo State, that are utilized for numerous purposes were analyzed. A total of five (5) samples were collected randomly from (hand-dug wells) located in the town. The physical tests investigated included taste, colour and odour. The chemical tests also included cations and anions determination while the bacteriological analyses carried out on the water samples involves determination of E– coli and total bacteria counts. Other parameters tested are the electrical conductivity, total hardness, trace elements, total dissolved solids and alkalinity. The result of the physical tests revealed that the water is colourless, odourless and tasteless, while the result of the chemical tests revealed that the pH ranges from 6.8–7.2, indicating that the water samples are slightly acidic to alkaline, temperature ranges from 27.1^{0}c – 30.4^{0}c, Electrical conductivity ranges from 418 – 748µS/cm, total hardness ranges from (125-156) ppm and Total dissolved solids ranges from 230-573 ppm. The analyzed cations and anions in the samples showed that ca^{2+}ranges from (13.1 – 20.4)mg/l, Mg^{2+} (21-28.9)mg/l, Na^+ (32.4-42.1)mg/l and K^+ (1.2-9.80) mg/l, while the anions showed that HCO_3^- ranges from (23.4-126.4) mg/L, CL (4.33-22.45) mg/L; SO_4^{2-} (11.4-60.3) mg/L and NO_3^{2-} (3.7-14.2) mg/L. The present of HCO_3- in the water samples revealed that the water is moderately soft, the soft to moderately hard nature of the water samples make them suitable for a wide range of use. This study is to assess if any of these randomly selected wells have been contaminated.

Keywords: Ipele, Hand- dug wells, Contaminants, Bacteria, NSDWQ

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1. INTRODUCTION

Majority of the households in Ipele are basically dependent on the traditional hand dug wells for their water supply, and are not concerned with water qualities accessed in these hand-dug wells. The quality of these water for direct consumption and other uses should be a concern to all and sundry as the quality of this water source can have great effect on the life and health of the inhabitants depending on it. Water "suitability" depends on the use for which it is intended. Hand dug well serves several purposes in Ipele town ranging from Brick making, livestock watering, fisheries, car wash, laundry services, domestic or even small scale irrigation. Some of these activities e.g. washing/ laundry are usually carried out within the vicinity of well, this in turn, can affect water quality since majority of wells in metropolis uses the traditional non-pulley system (i.e. bucket) in extraction of water. Drinking untreated surface water is potentially hazardous, and risks increases as reservoir use intensifies. Lack of pipe borne water further complicates the water quality situation in Ipele. Access to adequate urban water supply from the state water corporation is a serious problem facing the people of Ipele since the advent of democracy.

Several factors imparts on the quality of hand-dug wells such as surface run-off, dumping of solid waste, citing of pit latrines close to wells, automobile repair shops layout, unfettered disposal of industrial effluents in water bodies, disposal of untreated sewage are common sites and practices in the Ipele community which may indirectly influenced the groundwater quality. 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 Ajibadeet. al.(2008), Bello (2004) , Abimbola et al., (2002), Edetand Offiong (1998b) and Edet and Ntekim (1996). 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.

Researches has shown that underground water is highly susceptible to contamination that has led to outbreaks of water borne diseases (Eneh, 2011; Obiefuna and Sheriff, 2011; Shittu et al., 2008; Al-sabahi et al., 2009; Badmus, 2001). Akungbo (1990), Gideon (1999), Folorunsho (2010), Adediji and Ajibade, (2005) among others showed the relationship between well water quality and refuse dumpsites. Bacteriological qualities of groundwater (wells) in Nigeria have been reported to have high faecal coliform count exceeding recommended standards by WHO and NSDWQ (Ariziki, 1991; Gideon, 1999; Taylor et al., 2002). Human senses is limited to analyzing aesthetic quality of water, also is the chemical quality of drinking water , which cannot be analyzed merely by physical contact with water either.

The objectives of the study are to determine some physical, chemical and microbial parameters obtained from these hand dug wells, to compare the identified said parameters with the national and international standard: World Health Organization (WHO), Federal Environmental Protection Agency (EPA) United States for drinking water quality.

2. DESCRIPTION OF STUDY AREA

Ipele is a town in Owo Local Government Area of Ondo State of Nigeria. It lies between 7°00′ and 7°25′N and longitude 5°20′ and 5°45′E within the tropical rainforest zone of Nigeria. It covers a total land area of 345sqkm and has an estimated population of 0.1 million people. A soil moisture regime and an isohyperthermic soil temperature regime prevail in the area with total annual rainfall often exceeding 2000 mm, while the soil temperature has a narrow range of 27 to 28^{o}C, respectively. The area has a distinct geological formation; the Precambrian Basement Complex Granitic Rock. Geomorphologically, the local government area have strongly sloping to undulating landscapes of 8 to 12% slopes, while the central and southern parts have nearly level to gently sloping landscapes of 0 to 4% slopes. The qualities of water resources in the study area were tested for physicochemical and microbiological pollution. The samples were drawn from underground water resources.

Limitation of the study includes but not limited to accessibility and trust factor of the host community and funding which made the scope of the work is small.

Justification for the Research is mainly the need for potable drinking water for the inhabitants of Ipele-Owo. Therefore the justification for this work is to analyze water samples from hand-dug wells and compare the results with World Health Organization (WHO), Federal Environmental Protection Agency (EPA) United States for drinking water quality.

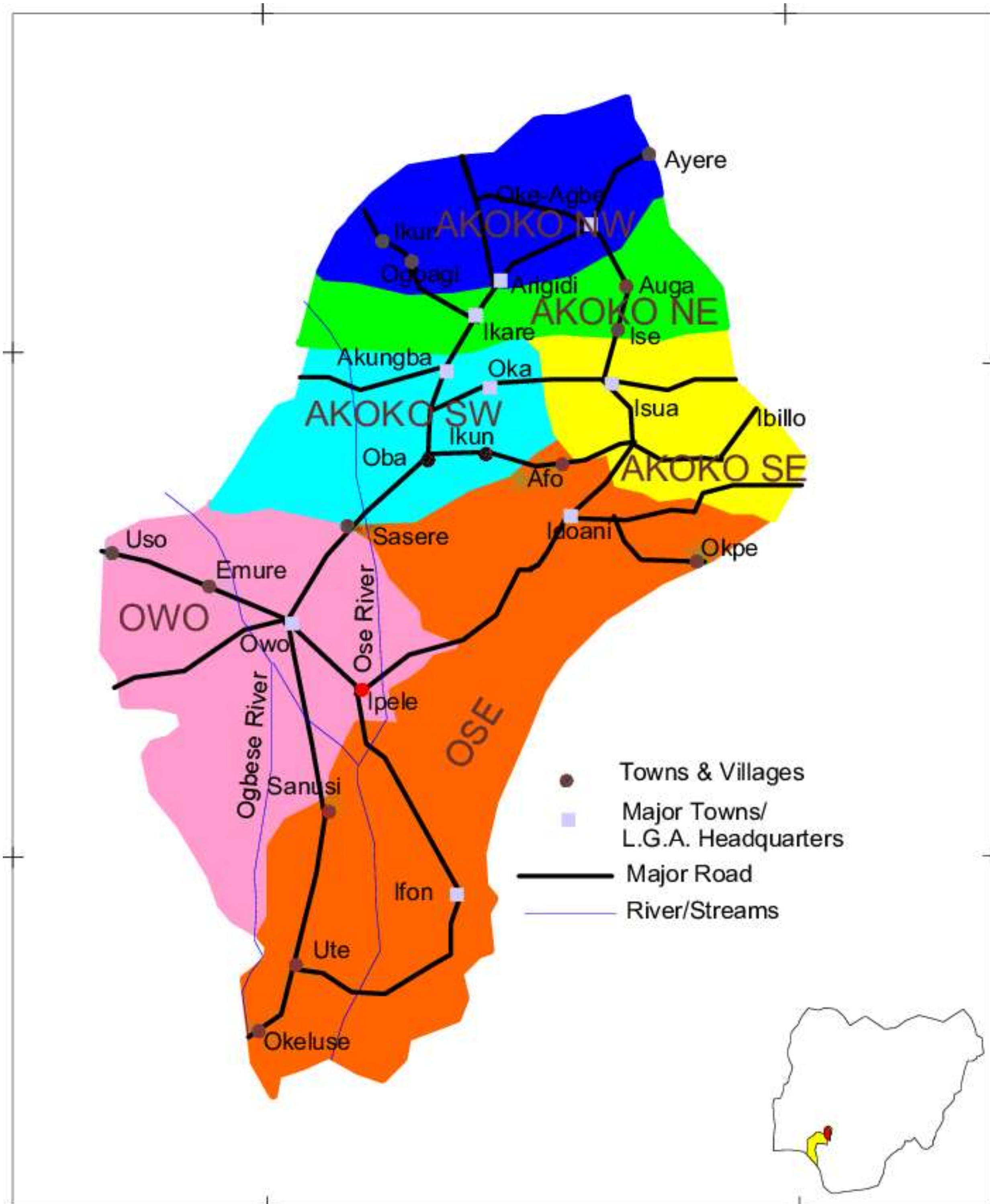

FIG 1. Location Map of the Study Area

3. CLIMATE AND VEGETATION

The climate is of tropical rainforest with two distinct seasons, the rainy season, (April-October) and dry season (November — March) with slight variations from year to year. The annual rainfall varies from 1500mm in the northern parts to 2,500mm in the Southern area. The temperature is relatively high throughout the year with an average daily temperature of about 270°C, with marked seasonal changes in rainfall and relative humidity. The State generally enjoys luxuriant vegetation. The vegetation consists of coastal forest and mangrove swamp forest in the south, moist lowland forest, and the forest savannah in the north.

4. REGIONAL GEOLOGIC SETTING

The study area lies within the Precambrian of southwestern Nigeria, which is a part of the Basement Complex of Nigeria. The study area is mostly underlain by crystalline rocks. These rocks 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
(iv) Unmetamorphosed minor acid and basic rocks

5. LOCAL GEOLOGY OF THE AREA

The study area is dominated by the migmatite gneiss (MGC) which are regarded as the most widespread of the main rock units in the Basement Complex of Nigeria. It is a heterogeneous assemblage of migmatites, orthogneisses, paragneisses and a series of basic and ultrabasic metamorphosed rocks (Rahaman 1976) The principal lithologies as observed in Ipele-Owo area are the granite gneiss, migmatite and grey gneiss. The granite gneisses are the most widely distributed rock type within the study area, occurring mostly as hills and flat lying exposures with colour varying from dark grey to light grey. The texture is granoblastic in the leucocratic quartz-and-feldspar-rich bands while the melanocratic bands are biotite-rich. Some traces of coarse garnet (notably along the river courses) are also common. The migmatites in the area are made up of granite gneisses, quartzofeldspathic gneisses, granites and basic rocks with quartzitic or pegmatitic intrusion cutting across and along the rock in different directions (Rahaman 1988). The grey gneiss is a grey foliated biotite-rich rock consisting of quartz with albite and /or hornblende gneiss of granodioritic to tonalitic composition. It is usually medium-to coarse-grained in texture with both linear and planar fabric. They commonly occur as hills, series of bouldery exposures and flat-lying exposure. In all the studied outcrops, it is mostly intruded by quartz veins. The paleosome includes the pegmatite and granite and they consist of light coloured minerals.

6. METHOD OF STUDY

The methods of study employed for this research work include field and laboratory studies. The field study involves collection of five (5) 5ml plastic water bottles which were rinsed with distilled water and sterilized to avoid contamination before they were filled with water collected at random from the hand dug wells in Ipele community. The water samples were collected inside the bottles which were carefully labeled to avoid mix up. Before the water samples were taken, the depth of the wells were estimated by counting the number of rings inside the well to give an idea of the depth in terms of feet (ft) and later converted to meters(m) for ringed wells, tape rule was used to measure the depth of the unringed ones. The depth of the wells sampled range from 18.2m to 26.0m (Thick overburden) and the temperature of the water were also measured with thermometer, which also ranges between 27.3^0c – 32.1^0c. The physical parameters such as odour, taste, and color were noted. Also, the geographical positions of the wells in these localities were accurately determined using Global Positioning systems (GPS). Other physical observation made on the field includes the nature and general condition of the wells. The samples were later preserved in the refrigerator at -4^0c until they were taken to the laboratory for chemical analysis. The laboratory method was aimed at determining the chemical constituents and bacteriological contaminant in the water samples collected. The water analyses was carried out at the Federal University of Technology; Water Laboratory in Akure, Ondo-State. The cations and Anions present in the water samples were determined. The cations are Na^+, Ca^{2+}, Mg^{2+} and Fe^{2+} while the Anions are HCO_3^{2-}, Cl^-, NO_3^- and So_4^{2-}. Also the samples were subjected to bacteriological analysis to determined Escherichia Coli (E- Coli) and total bacterial count.

7. RESULT AND DISCUSSION

The result obtained from the water analysis carried out is presented in Tables 1&2, and the compliance values are given in Table 3

TABLE 1: DESCRIPTION OF SAMPLE POINTS

LOCATION	LOCALITY	LONG.& LAT.	DEPTH OF WELL (m)	ALTITUDE (m)
HDW 1	DAIRO ODOLIE	N7^{0}8^{1}2.91'', E5^{0}40'15.3''	26m	298
HDW2	OKE OGBON	N7^{0}8^{1}5.85'', E5^{0}40'18.78''	20m	298
HDW3	ORIWO	N7^{0}8^{1}4.85', E5^{0}40'21.03''	18m	298
HDW4	OKE LOFI	N7^{0}7^{1}58.36'', E5^{0}40'35.80''	19m	290
HDW5	ONO OLA	N7^{0}7^{1}56.3'', E5^{0}40'36.04''	21m	290

TABLE 2: SUMMARY OF RESULTS

Parameters	HDW 1	HDW 2	HDW 3	HDW 4	HDW 5
Appearance	CLEAR	CLEAR	CLEAR	CLEAR	CLEAR
P^H	6.8	7.0	6.9	7.20	7.10
EC (µs/cm)	448	487	748	418	655
Colour	COLOURLESS	COLOURLESS	COLOURLESS	COLOURLESS	COLOURLESS
Total Hardness (ppm)	138.70	147.93	155.73	124.51	134.06
Odour	ODOURLESS	ODOURLESS	ODOURLESS	ODOURLESS	ODOURLESS
Alkalinity	56	74	134	66	70
TDS (ppm)	246.40	267.85	229.90	411.40	572.55
Turbidity (NTU)	1	0	1	2	2
Mg^{2+}	21.0	23.60	28.90	24.31	24.66
Ca^{2+}	16.70	20.40	14.80	20.08	13.10
K^+	1.20	1.64	9.8	4.60	0.12
Na^+	42.10	35	37	32.40	35.20
CL^-	8.84	4.33	8.40	7.88	22.45
$HC0_3^-$	23.40	112.30	126.40	23.40	80.40

SO_4^{2-}	22.40	11.40	33.00	16.4	60.30
Fe^+	1.40	0.78	2.60	2.00	3.22
NO_3^-	6.88	3.7	12.50	14.20	14.20
CO_3^-	12.44	34.60	25.30	12.50	36.87
AL_3^+	1.40	1.10	1.20	2.30	1.20
Si^{4+}	2.20	1.0	3.40	4.50	0.56
PO_4^-	48.76	18.85	27.40	28.80	182.40
E-coli	0	0	0	0	0
Coliform(per100ml)	3	2	3	2	3

TABLE 3: COMPLIANCE FOR PHYSICO-CHEMICAL ANALYSIS

PARAMETER	RANGE	HIGHEST DESIRABLE	MAXIMUM PERMISSIBLE	COMPLIANCE
DEPTH OF WELL	18-26			
TEMP.(^{0}c)	27.1^0c – 30.4^0c			
PH	6.8-7.2	7.0-8.9	6.5-7.5	WITHIN COMPLIANCE
EC (µS/cm)	418-748	900	1200	WITHIN COMPLIANCE
TH (ppm)	124.51-155.73	100	500	WITHIN COMPLIANCE
ALKALINE (mg/l)	56-134	100	100	WITHIN COMPLIANCE
TDS (ppm)	229.90-572.55	500	1500	WITHIN COMPLIANCE
TURBIDITY (NTU)	0-2	5	5	WITHIN COMPLIANCE
Mg^{2+}	21.0-28.9	50	50	WITHIN COMPLIANCE
Ca^{2+}	13.1-20.4	75	75	WITHIN COMPLIANCE
K^+	0.12-9.80			WITHIN COMPLIANCE
Na^+	32.4-42.0		200	WITHIN COMPLIANCE
CL^-	4.33-22.45	200	250	
$HC0_3^-$	23.4-126.4			
SO_4^{2-}	11.4-60.3	250	500	
Fe^+	0.78-3.22	1.0ppm	3.0ppm	WITHIN COMPLIANCE
NO_3^-	3.70-14.20	10	50	WITHIN COMPLIANCE
CO_3^-	12.44-36.87			
AL_3^+	1.1-2.3			
Si^{4+}	0.56-4.5			
PO_4^-	8.85-182.4			

These results from the sampled hand dug wells were compared with W.H.O (2004) standard values for drinking water. The depth of wells and G.P.S co-ordinates are also presented in Table 1. The PH value of water sample ranges from 6.8 – 7.2 with a mean of 7, compared with the World Health organization standard limits which range from 6.50 – 9.50. Almost all locations have water samples that range below the maximum permissible by WHO standards which indicated neutral .Therefore the study area is almost neutral. The temperature ranges from 27.1– 30.4^0c with a mean of 28.3^0c, this correlates with the ambient temperature of 28^0c at the time of collection. The electrical conductivity of the water samples in the study areas range from 418 – 748µS/cm with annual mean of 551.2µS/cm, compared with WHO standard limit (900µS/cm). All the samples are within the highest desirable by WHO standards. High conductivity in any sample might have been caused by the presence of some metallic ore bodies in the study area (high concentration of dissolved charged chemicals). The turbidity values of the water sample ranges from 0 – 2NTU with mean value of 1.2NTU. All samples fell within the recommended limits of WHO standard (5.0NTU). The total dissolved solids in the sampled wells ranges from 229.9–572.6ppm with a mean of 345.7ppm though the world health organization standard limits is (500ppm) but with a maximum permissible of 1500ppm. All the water samples fell within the stipulated standard limits which showed that the well water is acceptable and recommended for human consumption. High value of total dissolved solids in water can lead to gastro–intestinal irritation and stains of fabric. It can also cause kidney stones and other health problems like heart diseases and diabetes. The magnesium hardness values obtained ranges from 41 –49ppm with mean of 42.5ppm, although there is no standard specifications for magnesium hardness by the World Health Organization, the values obtained for this parameter are still within the limits for domestic consumption and within the The Bureau of Indian Standards (BIS) of 50ppm. The Ca^{2+} values range from 13.1 – 20.4ppm with a mean of 17ppm. Although the World Health Organization does not specify the particular standard limit but the National Foods and Drugs Administration Control (NAFDAC) maximum allowed limits for calcium ion is(75ppm). Therefore, water samples are within the acceptable limits. The high value of calcium in drinking water may either be attributed to its abundance in the earth crust or are released as weathering product of feldspars, amphibole and pyroxenes. The concentration of magnesium in the samples varies from 21 – 28.9mg/L with an average of 24.5mg/L, though the World Health Organization maximum permissible limit for Mg^{2+} is (20mg/L). All the water samples analyzed fell within this specification. This showed that the water samples are portable for human consumption and other domestic purposes. The high concentration of magnesium in the sampled hand dug wells may have arisen from the leaching of minerals such as biotite, olivine, pyroxene or clay minerals. This corroborates the work of Elueze et al, 2001. The concentration of chloride ranges from 4.33 – 22.5 with a mean of 10.4mg/L. The World Health Organization maximum permissible limit for chloride is(250mg/L).Therefore all water samples in the study areas fell within the range of the WHO standard limits. Sources of Cl^- in water include migmatitic rocks, fertilizers, human excrement and air (Freeze and Cherry, 1979).Also, chloride concentration is influenced by recharge from meteoric water, weathering and subsequent release of ions from the underlying basement rocks. The concentration of nitrate in the study area ranges from 3.7 – 14.2mg/L with a mean of 10.3mg/l and the standard recommendation for nitrate as portable water by WHO is (50mg/L). Therefore, the water sample in the study areas fell within the stipulated range by WHO. Some traces of nitrate observed in the water samples might have originated from the use of artificial fertilizer for farming in the study area and waste dump sites in the area, which probably leached and percolated into the soil and polluted the water. (Tredoux et al 2000). The Iron concentration in the study area ranges from 0.78– 3.2 while the WHO standard limits is (3mg/L). It implies that the wells water in the area fell within the stipulated standard limit and good for human health. Sources of iron in water include weathered amphibolites, magnetite, biotites and garnets. The concentration of sodium (Na+) ranges from 32.4 -42 with a mean of 36.4 while the stipulated standard limits for sodium concentration in the quality water is 200mg/L. Hence, it is also permissible within the WHO standard limit. The high concentration of sodium in the samples might be due to close contact or relationship between the bedrocks. Nevertheless, the concentration of sodium still fell within the acceptable range of good quality water which is good for human health. The concentration of sulphate varies from 11.4 – 60.3 while the maximum permissible value is 500mg/L and the highest desirable limit for WHO standard is 250mg/L. However, the values also fell below the desirable standard. Sulphate ions or concentration occur in natural unaffected water which account for up to 50mg/l, though high concentration above 50mg/l as recorded in Hdw5 might have resulted from contact with certain geological formations such as gypsum reserves and pyrite in quarries. Also, the traces of sulphate in the water sample might have resulted from improper disposal of sewage and refuse in the area. The total hardness ranges from 125 – 156mg/l with a mean of 142mg/l while the WHO accepted value for total hardness is 100mg/L and maximum permissible limits is500mg/L. It shows that all the water samples fell within standard limit which is acceptable for drinking water. The hardness of the water may occur due to the excessive presence of calcium and magnesium ions (Ca^{2+} and Mg^{2+}) and also chloride. Potassium concentration ranges from 0.12 – 9.8 with a mean value of 3.5mg/l though the WHO standard limit does not specify the particular standard limit for potassium, but NAFDAC maximum allowed limits for potassium (k^+) is 10.0mg/L. Therefore, Hdw10 has highest values which exceed the NAFDAC maximum allowed limits. The dominance of potassium ion in most of the wells may be attributed to their relative concentrations in the minerals present in the basement complex rocks. Such minerals are microcline and feldspars in granite gneiss. The $CO3^{2-}$ ranges from 12.4 –36.9mg/l with a mean value of 24.4mg/l while the WHO standard limit is 100mg/L. Most of the water samples fell within the maximum permissible limits. Generally, alkalinity is caused by HCO_3^-, CO_3^- and OH^- component in a raw or treated water supply. From the portability point of view, alkalinity is not a significant parameter since variations of concentration from 56 to 125mg/L are expected and the extremes of these values are tolerated in the water supply.(Dezuane,1996). The concentration of bicarbonates ranges from 56 – 134 with a mean value of 80 while the WHO standard for quality water is not stated. In the study areas, Hdw2, Hdw3, and Hdw5 have the highest concentration of HCO_3-. Possible sources of

bicarbonate ion in water are carbon dioxide of the air and organic matter. Therefore, its stability in water however depends on the PH of the water. The total coliform count ranges from 2 -3 which is normally compared with stipulated standard limits. The amount of E-coli present in water samples is 0 with the maximum permissible standard limits for E-coli in high quality water is zero colony. All samples fall within the maximum permissible standard limits of World Health Organization. High number of E-coli in drinking water can portend water borne diseases and sickness to the people living in the study area. Therefore, proper treatment must be put in place to avoid widespread water borne disease and sickness like Diarrhea, Dysentery, Typhoid, and Cholera etc. The rocks in the study area contribute to the quality of groundwater in terms of their geology and chemistry. Most of the rocks serve as aquifer which is highly permeable and porous. The basement complex of the study areas determines the PH values of each hand-dug well studied and analyzed. The PH Values of the water samples range from 6.8-7.2 with a mean of 7 which indicated that the wells are slightly acidic to neutral. Thus, the order of PH scale of water samples in the study areas is slightly Acidic-Alkaline. It was observed that the Calcium Concentration present are normal compared with the NAFDAC maximum allowed limit for Calcium ion (75mg/l). The (mg^{2+}) values falls within the world Health Organization maximum permissible of (20mg/l) which indicate that the water samples is good for human consumption and other purpose. The mean concentration of cations therefore is in order of $Na^+ >^+Ca^{2+} > Mg^{2+} > k^+ > Fe^{2+}$ while for the anions, is $Hco_3 > Cl^- > So_4^{2+} > No_3^-$.Some of the Chemical analysis such as nitrate (NO_3^{2-}) is low which shows minimal contribution from agriculture practices and absence of direct sewage disposal in the vicinity of the well water. (Tredoux et al, 2000). It represents the most highly oxidized phase in the Nitrogen Cycle and normally reaches important concentrations in the final stages of biological oxidation. The nitrate content for most water is not generally related to any geological formation. When in excess, it mostly contributes to illness known as infant methaemoglobimemia (normally known as blue baby). Nitrates are generally formed naturally in the soil by the microbial degradation of nitrogenous organic material such as proteins. Ammonium ions are produced first and these are then biologically oxidized to nitrate. The source of HCO_3^- in the study area can be attributed to the influence of carbon dioxide from recharged water (Tijani, 1994). The degree of pollution is also aided by the shallow depth of the wells which ranges
from 21 to 24m. According to GeldReich (1981) 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 presence of Na^+ K^+, CL^- is a function of the host rock and products of weathering. As water moves through the rocks underlain by clay formations, some ionic exchange takes place and the water takes into solution the different ions concentration invariable quantities which infiltrates underground and form part of the underground water. The geology and topography of the study areas has also influenced the supply and occurrence of groundwater. It was observed that the wells are concentrated in the lowland area, the dominance of some of the chemical parameters such as potassium ions may be attributed to their relatively concentrations of minerals present in the basement complex rocks such as minerals like microcline and orthoclase feldspars in granite gneiss. Potassium is very essential for growth and well being of living Organisms. It regulates the acid-base balance. Sodium is another abundant compound which is very soluble. Its falls within the WHO standard limit, Hence, high concentration of Sodium is detrimental to consumers. Excess in the body cause heart disease (voshoey, 1985).Thus, the recommended concentration of sodium in drinking water is 200mg/l. Also, excessive concentration of magnesium is undesirable in domestic water because it has cathartic and direct effect when associated with the level of sulphates. Hence, magnesium concentration in samples falls within the World Health Organization (20mg/l). The total alkalinity (mg/l) of the wells in the study area increases with total hardness, while there is a uniform and progressive rise between the PH and total dissolved solids in the wells of the study area.

8. CONCLUSION AND RECCOMENDATION

The present study has provided information on the geologic setting and hydrogeochemistry of the study area. The main lithologic unit in the area includes-Migmatites-Gneiss Complex (MGC), which are part of the basement rocks of southwestern Nigeria. The physiochemical and bacteriological analyses of the water samples were carried out, in order to determine the portability status of these wells. Hence, these following conclusions were made about the hand dug wells in the area.(i).It is concluded that the pH values measured for the wells showed that the water samples are slightly acidic to alkaline. Thus, the Ph values falls within the world health organization limits, hence, the water samples are acceptable for human consumption.

(ii)The total coliform count (ranges 2-3) and E-coli (0) are within the WHO standard. This means that the wells are safe for human consumption.

(iii) From all indications and analysis carried out on the wells, it is also concluded that all natural water contains some dissolved minerals which is influenced by the chemical constituents derived from their geological formations.

Therefore, all the wells have above 95% compliance, thus making it suitable for human consumption. Having assessed the quality of hand dug well in the study areas, the following recommendation are proffered in the enhancement of quality of the water supply from the existing wells and most especially to some sets of wells. These recommendations are as follows.

1. The well should be treated with equal proportion of Alum and hydrate lime using 200-375grams on every estimated 500litres of water in each wells and this should be done in at least every six months.
2. The existing wells should be well kept and should be well developed while the uncovered ones are to be provided with good covers to prevent pollution.
3. The community in general should be kept under good sanitary condition by encouraging individual's house owners to provide modern toilet facilities for their conveniences.
4. The inhabitants should adopt the modern way of sewage disposals.
5. Finally, Government at all levels are advised to construct and develop good boreholes which penetrate into the aquiferous zones and encourage good sanitary conditions of the communities.

REFERENCES

Adegoke C.W. and Owolabi A.,(1988). Groundwater prospects in Basement rock of southwestern Nigeria Journal of African Earth Science Volume 7. No.1 pp 227-235

Abimbola,A.F, Ajibade,O.M; Odewande, A.A; Okunola, W.O; Laniyan, T.A.; Kolawole, T. (2008): Hydrochemical characterization of water resources around the semi-urban area of Ijebu-Igbo southwestern, Nigeria. Journal of water resources Voumel.20: 10-15.

Ako B.D, Adeniyi F.I and Adepoju J.F.,(1990). Statistical tests and Chemical, quality of shallow groundwater from a metamorphicTerrain Ile-Ife / Modakeke, S.W Nigeria, Journal of African Earth Science, vol. 10. No3, pp 602-613.

Dada, S.S. (2006). Crust forming ages and Proterozoic crustal evolution in Nigeria, a reappraisal of current interpretations. Precambrian Research, Volume. 8, pp 65-74.

Dezuane J., (1996). Handbook of drinking water Quality 1 John Dezuane- 2nded. Copyright O 1997 by John wiley& Sons Incorporated.

John Dezuanep.k. Ha. Davis, S .N ; Deweist R.J M., (1966).Hydrogeology John wiley and Sons, New York, pp463

Edet, A.E. and Offiong O.E., (1998b): Surface water quality evaluation in Odukpani, Calabar flank, Southwestern, Nigeria. Journal of Environmental Geology 36(3/4): 343-348.

Edet A.E., and Ntekim E.E.U., (1996): Heavy metal distribution in ground water from Akwa Ibom State, eastern Niger delta- A preliminary pollution assessment. Global Journal of Pure and Applied Sciences 2(1): 67-77.

Elueze, A.A., (2000). Compositional appraisal and petrotectonic Significance of the Imelu banded ferruginous rocks in the Ilesha Schist belt, southwestern Nigeria Journal of mining and Geology, Volume.36, pp 8-18.

Elueze, A.A; Ephraim, B.E., and Nton, M.E., (2001). Hydrochemical assessment of surface water in part of southeastern Nigeria. Mineral wealth. Volume . 119, pp45-58.

Freeze R.A and Cherry J.A.C., (1979). Groundwater prentice Hall, Engle wood Cliff's pp 604

Geldreich, (1981). E.coli detection from river waters, Environmental science publications. 5.

Hutchinson and Ridgeway (1976). Microbial Agents of Drinking, Water Supply. "Aquatic microbiology shrew and strainer, Society of Applied bacteriological Technical series No.7, pp41-50

Joung H.M., Miller W.W., Mahammar C.N and Gultjens J.C.A..,(1979). A generalized water quality index based on multivariate factor analysis. Journal Environmental Quality 8: 95-?

Nishida N., Miyai M., Tada F, and Suzuki s., (1982).Computation of Index of pollution by heavy metal in river water. Environmental pollution 4: 241-?

Prasad B. and Bose J.M., (2001). Evaluation of heavy metals in ground water near mining area and development of heavy metal pollution index. Journal Environmental science and Health A 34(1):91-102

Rahaman, M.A and Malomo, S, (1983). Sedimentary and crystalline rocks of Nigeria. In tropical soils of Nigeria in Engineering Practice (S.A Ola, ed), A.A Balkema, Rotterdam, pp17-38.Tijani.M.N. 1994 - Hydrogeochemical assessment of groundwater in moro area, kwara state, Nigeria. Evironmental Geology 24(3), pp 194 – 202.

Tredoux G,Tana A.S and Engelbrecht (2000). The increasing nitrate hazard in groundwater in the rural areas paper presented at Water institute, South African conference, may, Sun City World Health Organisation (WHO) 2004 Guidelines for Drinking Water Quality, International Standards for Drinking Water Volume.1 Geneva W.H.O. Pg. 130.

Tredoux G,Tana A.S and Engelbrecht (2000). Theincreasing nitrate hazard in groundwater in the ruralareas paper presented at Water institute, SouthAfricanconference, may, Sun CityWorld HealthOrganisation (WHO) 2004
.
Guidelines for DrinkingWater Quality, International Standards for DrinkingWater Volume.1 Geneva W.H.O. Pg. 130.Hutchinson and Ridgeway (1976). Microbial Agents of Drinking, Water Supply. "Aquatic microbiology shrew and strainer, Society of Applied bacteriological Technical series No.7, pp41-50

Joung H.M., Miller W.W., Mahammar C.N and Gultjens J.C.A..,(1979). A generalized water quality index based on multivariate factor analysis. Journal Environmental Quality 8: 95-?

Nishida N., Miyai M., Tada F, and Suzuki s., (1982). Computation of Index of pollution by heavy metal in river water. Environmental pollution 4: 241-?
Prasad B. and Bose J.M., (2001). Evaluation of heavy metals in ground water near mining area and development of heavy metal pollution index. Journal Environmental science and Health A 34(1): 91-102.
Hutchinson and Ridgeway (1976). Microbial Agents of Drinking, Water Supply. "Aquatic microbiology shrew and strainer, Society of Applied bacteriological Technical series No.7, pp41-50

Joung H.M., Miller W.W., Mahammar C.N and Gultjens J.C.A..,(1979). A generalized water quality index based on multivariate factor analysis. Journal Environmental Quality 8: 95-?

Nishida N., Miyai M., Tada F, and Suzuki s., (1982). Computation of Index of pollution by heavy metal in river water. Environmental pollution 4: 241-?
Prasad B. and Bose J.M., (2001). Evaluation of heavy metals in ground water near mining area and development of heavy metal pollution index. Journal Environmental science and Health A 34(1): 91-102.

Voshoey (1985): Water Resources Engineering 3rd edition, Edward Arnold Publisher United States of America (USA) pp898-948.

World Health Organization (1993): Guidelines for drinking water quality, volume 1, recommendation, 2nd edition, World Health Organization Geneva.