International Journal of Engineering Research and Development
***e*-ISSN: 2278-067X, *p*-ISSN: 2278-800X, www.ijerd.com**
Volume 3, Issue 5 (August 2012), PP. 10-23

Determination of Groundwater Physiochemical Parameters of Shallow Aquifers in Agbowo and Ajibode Communities in Oyo State, Southwestern Nigeria

O.O. S. Ojo[1] and O.S. Awokola[2]
[1]*Department of Civil Engineering, University of Ibadan, Oyo State, Nigeria*
[2]*Department of Civil Engineering, Federal University of Agriculture, Abeokuta, Ogun State Nigeria.*

Abstract—Abundant as it may seem, in Nigeria, access to clean and potable water is a great challenge. Hence, the reason the physiochemical properties of the groundwater in Agbowo and Ajibode communities in Oyo State, Southwestern Nigeria was analyzed. Water samples were collected from fifteen shallow wells, with varying depths. The water quality parameters were analyzed in accordance to standard methods. The ground water analysis reviewed includes pH, electrical conductivity, total dissolved solids (TDS), total suspended solids (TSS), turbidity, and hardness. Others include inorganic chemical constituents and the presence of coli form organisms. Results indicated that the parameters measured have some falling within the limits and some above the maximum permissible limit of Standard Organization of Nigeria (SON), European Union (EU) and World Health Organization (WHO) for drinking water. In general, the data revealed that maxima and minima concentrations of the priority physiochemical water quality parameters examined in the 15 water sources were mostly within the target water quality range (TWQR) for domestic use with little exceptions at some points, making these 15 water sources available in the area less potentially health hazardous to inhabitants. The overall implication of this observations, call for sustenance and improved water resources management strategy for the area in order to prevent the deterioration of the water sources quality, which may pose associated health risk and environmental hazard.

Keywords—groundwater quality, physiochemical, water samples

I. INTRODUCTION

Groundwater is a valued fresh water resource and constitutes about two-third of the fresh water reserves of the world (Chilton, 1992). It is estimated that the groundwater reservoir of the world is about 5.0 × 1024 L, this volume is more than 2,000 times the volume of waters in all the world's rivers and more than 30 times the volume contained in all the world's fresh water lakes (Buchanan, 1983).

There is an increasing need to protect the quality of Nigeria's water resources from degradation due to domestic, municipal, agricultural and industrial activities, which interferes with the water uses at any scale. Quality of drinking water is of highest importance and this depends on source and level of contamination or pollution.

The rate of urbanization in Nigeria is alarming and the major cities are growing at rates between 10 to 15% yearly. In studies relating to the Nigerian experience, attention has been raised on the neglect of studies on rain, well and borehole water quality as a combined work, thereby resulting in lack of literatures, especially on borehole water quality assessment due to the belief that it is pured through the natural purification process (Efe, 2002a). Ayoade & Oyebande, (1983) reported that this neglect has impaired adequate information or knowledge of the quantity, quality and pattern of distribution of Nigeria's water resources.

Sangodoyin (1993) observed that the unsanitary mode of disposal of wastes, such as defecation in streams and the dumping of refuse in pits, rivers and drainage channels as seen in most Nigerian urban settlements could be expected to affect surface and groundwater quality.

Groundwater is abstracted through hand-dug wells; hand-pump operated shallow-wells and submersible pump operated deep well or boreholes (Ojo, 2002). Park and Park (1994) divided wells into two namely: shallow and deep wells, depending on the location of the impervious strata for which the water is obtained. Also, based on the mode of construction, wells can be classified into three categories namely:

1. Hand-dug well
2. Bored well
3. Driven well (Sangodoyin, 1987).

Shallow wells are generally less than 15 m deep while deep wells are greater than 50 m in depth (Hofkes, 1981). In this study, the groundwater samples considered were abstracted from 15 shallow hand-dug wells in Agbowo (AG) and Ajibode (AJ) in Ibadan, South-Western Nigeria.

II. PHYSICOCHEMICAL QUALITY

The term physicochemical quality is used in reference to the characteristics of water which may affect its acceptability due to aesthetic considerations such as colour and taste; produce toxicity reactions, unexpected physiological responses of laxative effect, and objectionable effects during normal use such as curdy precipitates (WHO, 2008) (Tables 5 & 6).

The physico-chemical parameters analyzed include, temperature, turbidity, pH, total dissolved solid (TDS), electrical conductivity (E.C), total hardness (TH), chloride (Cl^-), nitrate ($N0_3^-$), calcium (Ca^{2+}), sulphate (SO_4^{2-}), phosphate (PO_4^{3-}), and copper (CU^{2+}). Coliform tests were the bacteriological analysis performed for this study.

III. STUDY AREA

Ibadan (Oyo state, Nigeria) is the largest city in West Africa and the second largest in Africa, with land size covering an area of 240km^2. The city is located on geographic grid reference longitude 3º 58'E, and latitude 7º 22'N (Filani, 1994). The study area has an altitude generally ranging from 185 to 222 m above mean sea level and Ibadan is drained by three major river basins (Ogunpa, Ona and Ogbere). It is surrounded by secondary rainforest as well as a savannah. Spatially, it sprawls over a radius of 12-15 km and experiences a mainly tropical climate with an estimated annual rainfall of about 1250 mm (UNCHS/UNEP, 1997). The study area comprise of 2 local government areas (Akinyele and Ibadan North West). The study area (Ajibode and Agbowo) and sampling points are shown in Figures1 & 2. The sampling locations GPS and well depths are as shown in Tables 1& 2 below:

Table 1: Depth of the wells in the study area

Depth of well (m)	Number	Percentage
<5	13	86.67
>5 - 10	2	13.33
Total	15	100

Table 2: Groundwater Sampling Location Description					
Sampling No	Wells	SAMPLING Locations	Latitude/ Longitude	Elevation (meters)	Depth (meters)
1	AJ01	Ajibode 01	N07˚27.505′ E003˚53.601′	204	2.35
2	AJ02	Ajibode 02	N07˚27.510′ E003˚53.661′	189	1.53
3	AJ03	Ajibode 03	N07˚27.535′ E003˚53.643′	194	6.21
4	AJ04	Ajibode 04	N07˚27.586′ E003˚53.547′	196	4.05
5	AJ05	Ajibode 05	N07˚27.547′ E003˚53.490′	186	4.64
6	AJ06	Ajibode 06	N07˚27.510′ E003˚53.572′	185	5
7	AJ07	Ajibode 07	N07˚27.665′ E003˚53.478′	188	1.24
8	AG01	Agbowo 01	N07°26.937' E003°55.188'	221	2.6
9	AG02	Agbowo 02	N07°26.951' E003°55.126'	222	1.4
10	AG03	Agbowo 03	N07°26.950' E003°55.108'	212	4.3
11	AG04	Agbowo 04	N07°27.009' E003°55.131'	220	4.06
12	AG05	Agbowo 05	N07°27.033' E003°55.182'	210	4.72
13	AG06	Agbowo 06	N07°27.041' E003°55.201'	209	5.33
14	AG07	Agbowo 07	N07°26.995' E003°55.149'	203	1.88
15	AG08	Agbowo 08	N07°27.064' E003°55.184'	203	1.24

IV. MATERIALS

Sampling

Well water samples

A total of 15 shallow well water samples were collected in Agbowo (AG) and Ajibode (AJ). The water level in each well was measured using an ELE water level indicator. The samples were collected in pre-cleaned 1 litre plastic bottles in the morning and were taken for physiochemical analysis in the laboratory.

Methods

The temperature was measured at the point of sample collection. A thermometer was used to determine the temperature of the samples, the Hach 2000 pH meter was used to measure the pH of the samples, turbidity was estimated by nephelometric method using Hach model 2100AN Turbidimeter and the CIBA-CORING conductivity meter was used to measure electrical conductivity. Total suspended solids (TSS) were determined by filtration and gravimetric. TDS was measured by gravimetric. The Hach DR 2700 Spectrophotometer was used for chemical analysis.

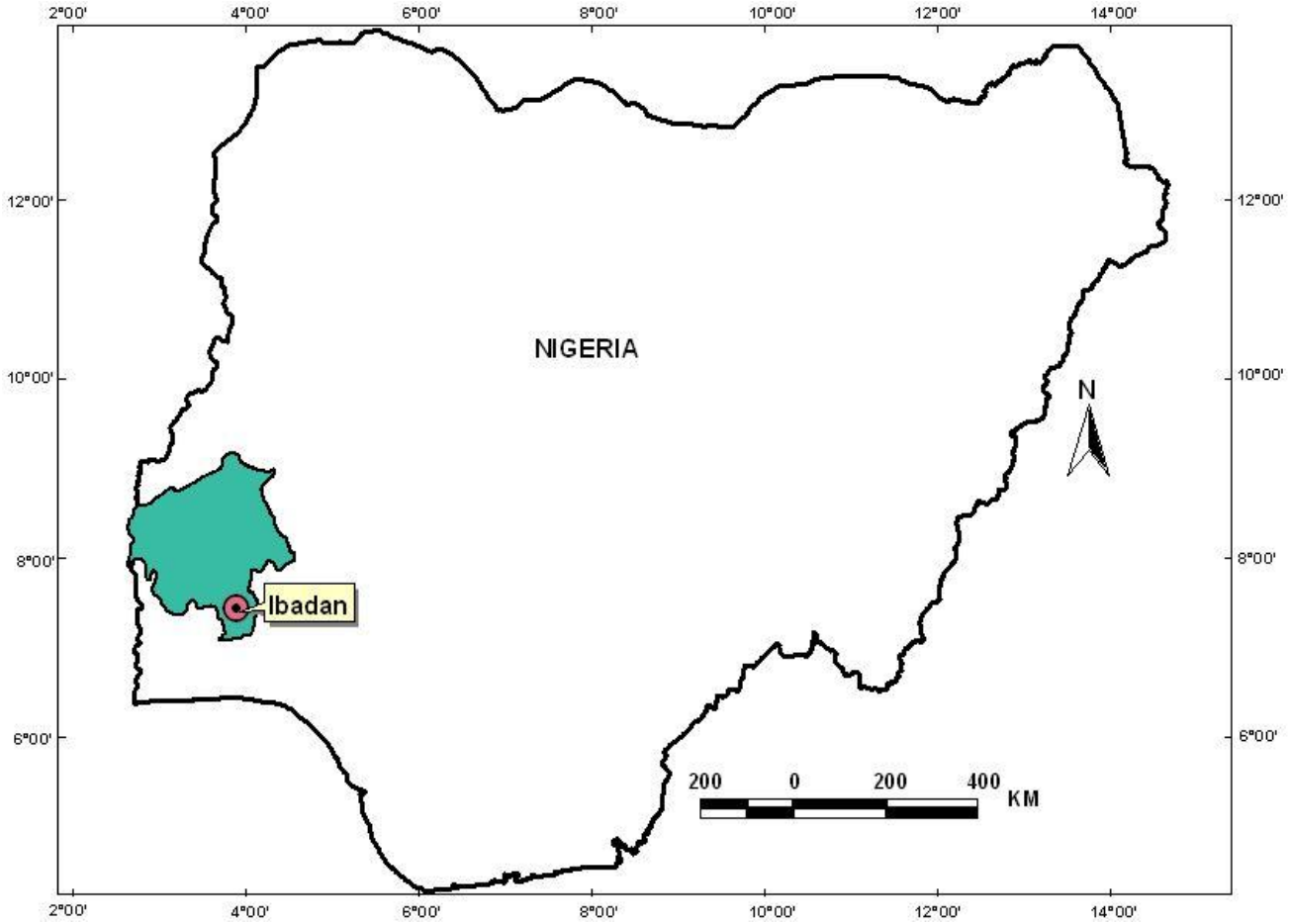

Figure 1: Map of Nigeria Showing Oyo State and Location of Ibadan

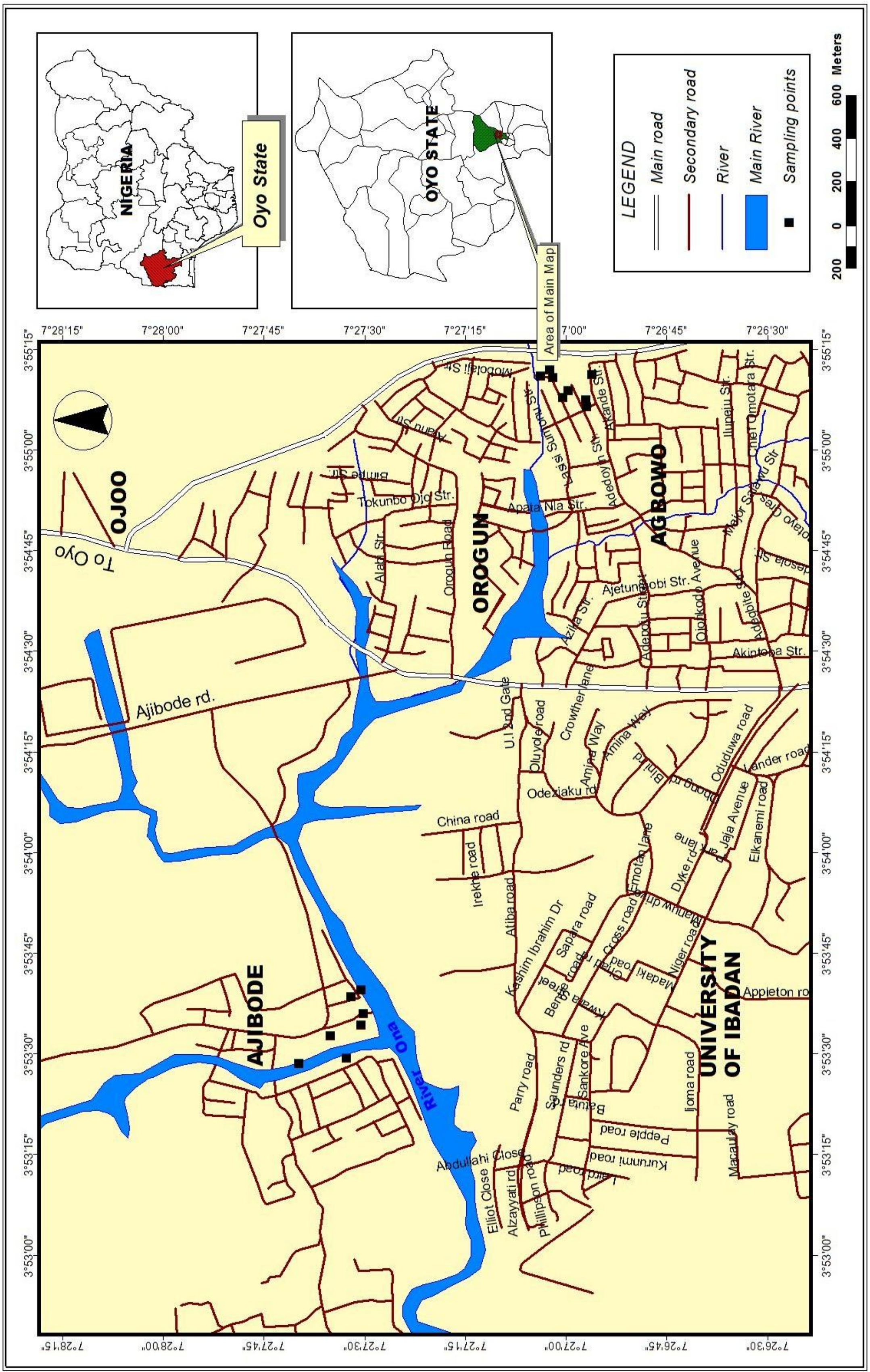

Figure 2. Map of Study area indicating the sampling points

Table 3: Characteristics of well water in Ajibode

Parameters	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4	Sample No. 5	Sample No. 6	Sample No. 7	Ranges			
								Min	Max	Mean	S.D
Temperature	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	**27.4**	**0.0000**
pH value	7.07	6.84	6.93	7.33	7.10	6.92	6.77	6.84	7.33	**6.99**	**±0.1886**
Colour (TCU)	10.0	5.0	5.0	15.0	10.0	10.0	5.0	5.0	15.0	**8.57**	**±3.7796**
Odour	Unobj.	Unobj.	Unobj.	Unobj.	Unobj.	Unobj.	Unobj.	Unobj.	Unobj.	Unobj.	Unobj.
Acidity	0.1	0.3	0.2	0.1	0.1	0.4	0.3	0.1	0.4	**0.21**	**±0.1215**
Total solid (mg/l)	684.30	431.70	162.50	351.00	285.30	754.00	342.90	162.50	754.00	**430.24**	**±214.4640**
Suspended solids (mg/l)	343.10	195.00	25.40	53.70	158.50	370.70	158.80	25.40	370.70	**186.46**	**±131.444**
Hardness (mg/l)	191.00	125.00	93.00	169.00	77.00	222.00	95.00	77.00	222.00	**138.86**	**±55.6550**
Calcium (mg/l)	123.00	78.00	65.00	126.00	48.00	110.00	64.00	48.00	126.00	**87.71**	**±31.5104**
Magnesium (mg/l)	68.00	47.00	28.00	43.00	29.00	112.00	31.00	28.00	112.00	**51.14**	**±30.2844**
Chloride (mg/l)	184.00	109.00	67.00	112.00	52.00	217.00	69.00	52.00	217.00	**115.71**	**±62.7102**
Nitrate (mg/l)	6.00	4.50	1.60	2.80	4.70	12.00	3.60	1.60	12.00	**5.03**	**±3.3836**
Turbidity (NTU)	4.81	8.44	0.73	1.59	5.89	2.56	1.07	0.73	8.44	**3.58**	**±2.8836**
Electrical Conductivity (µs/cm)	823.00	479.00	285.00	588.00	293.00	877.00	346.00	285.00	877.00	**527.29**	**±24.5704**
Sulphate (SO_4^{2-}) (mg/l)	31.00	27.00	16.00	28.00	15.00	48.00	20.00	15.00	48.00	**26.43**	**±11.3263**
Phosphate(PO_4^{3-}) (mg/l)	0.59	1.10	0.26	0.63	0.26	0.09	0.25	0.09	1.10	**0.45**	**±0.3455**
Copper (Cu^{2+}) (mg/l)	0.12	0.28	0.04	0.04	0.17	0.29	0.18	0.04	0.29	**0.16**	**±0.1018**
Manganese (Mn^{2+}) (mg/l)	Nil	0.016	0.010	0.035	0.034	0.004	0.031	0.004	0.035	**0.02**	**±0.0133**
Chromium (Cr^{6+}) (mg/l)	0.01	0.03	0.01	Nil	0.04	0.03	0.05	0.01	0.05	**0.03**	**±0.0160**
Bacteria count/100ml	30	TNTC	TNTC	TNTC	TNTC	TNTC	25				
E.coli (24hrs)	90	>160	>160	160	160	>160	90				

Table 4: Characteristics of well water in Agbowo

Parameters	Sample No. 8	Sample No. 9	Sample No. 10	Sample No. 11	Sample No. 12	Sample No. 13	Sample No. 14	Sample No. 15	Sample No.	Ranges		
									Min	Max	Mean	S.D
Temperature	29.3	29.3	29.1	29.4	29.2	29.3	29.5	29.4	29.1	29.5	**29.3**	**±0.1246**
pH value	6.33	7.10	7.55	7.15	6.92	7.38	7.67	8.24	6.33	8.24	**7.3**	**±0.5653**
Colour (TCU)	10.0	5.0	20.0	10.0	10.0	10.0	5.0	180.0	5.0	180.0	**31.25**	**±3.7796**
Odour	Unobj.	Unobj.	Unobj.	Unobj.	Unobj.	Unobj.	Unobj.	Unobj.	Unobj.	Unobj.	Unobj.	Unobj.
Acidity	0.5	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.5	**0.16**	**±0.1408**
Total solid (mg/l)	737.20	902.70	771.40	1427.30	1325.70	937.20	625.00	1708.00	625.00	1708.00	**1054.3**	**±385.7625**
Suspended solids (mg/l)	256.20	164.50	398.90	580.30	762.50	368.20	129.60	700.00	129.60	762.50	**420.0**	**±239.3365**
Hardness (mg/l)	120.00	197.00	195.00	332.00	214.00	266.00	203.00	228.00	120.00	332.00	**219.4**	**±61.1787**
Calcium (mg/l)	64.00	96.00	94.00	138.00	105.00	50.00	66.00	108.00	50.00	138.00	**90.1**	**±28.6777**
Magnesium (mg/l)	56.00	101.00	101.00	194.00	109.00	216.00	137.00	120.00	56.00	216.00	**129.3**	**±52.4207**
Chloride (mg/l)	203.00	290.00	270.00	203.00	268.00	305.00	265.00	430.00	203.00	430.00	**279.3**	**±71.2616**
Nitrate (mg/l)	6.80	25.00	9.10	20.00	10.80	3.50	12.00	1.30	1.30	25.00	**11.1**	**±8.0143**
Turbidity (NTU)	0.77	8.21	14.20	3.03	3.85	0.95	5.79	118.00	0.77	118.00	**19.4**	**±40.1011**
Electrical Conductivity (µs/cm)	1081.00	1618.00	1057.00	1931.00	877.00	1456.00	1076.00	2011.00	877.00	2011.00	**1388.4**	**±43.1406**
Sulphate (SO_4^{2-}) (mg/l)	15.00	28.00	12.00	10.00	14.00	11.00	9.00	95.00	9.00	95.00	**24.3**	**±29.2074**
Phosphate(PO_4^{3-}) (mg/l)	0.22	0.79	0.13	0.49	0.20	0.60	0.43	6.20	0.13	6.20	**1.1**	**±2.0596**
Copper (Cu^{2+}) (mg/l)	0.08	0.08	0.00	0.00	0.09	0.12	0.12	0.00	0.08	0.12	**0.1**	**±0.0530**
Manganese (Mn^{2+}) (mg/l)	Nil	0.079	Nil	0.027	Nil	0.029	Nil	0.335	0.027	0.035	**0.05**	**±0.0133**
Chromium (Cr^{6+}) (mg/l)	0.01	0.04	0.05	0.06	0.05	0.04	0.02	Nil	0.01	0.06	**0.04**	**±0.0177**
Bacteria count/100ml	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC				
E.coli (24hrs)	>160	>160	>160	>160	>160	>160	>160	>160				

V. RESULTS, ANALYSIS AND DISCUSSION

Results of the assessment of physiochemical parameters are presented in Tables 3 & 4 respectively. The standard values recommended by Nigerian Standard (Standard Organization of Nigeria (SON, 2007)), World Health Organization (WHO, 2008), and European Union (EU) are presented in table 5 & 6. The chart of the nutrient loads in the wells are presented in figures 3 - 12.

Table 5: Various Drinking Water standards and guidelines

Parameter	Nigerian Standard	WHO Standard	EU Standard
Temperature	Ambient	28	12 (Max. 25)
pH (units)	6.5-8.5	7.0 - 8.5(Max. 9.2)	6.5-9.5
Conductivity (µs/cm)	1000	1200	400
Odour	Unobjectionable	Unobjectionable	0 (Max. 2-3)
Colour (TCU)	15	5 (Max. 50)	1 (Max. 20)
Turbidity (NTU)	5	5 (Max. 25)	1 (Max. 10)
Calcium (mg/l)	75	75(Max. 200)	-
Magnesium (mg/l)	-	30(Max. 150)	
Total Dissolved Solids (mg/l)	500	1000	-
Total Hardness (as $CaCO_3$)	100	100 (Max. 500)	-
Chloride (Cl^-)(mg/l)	100	250	250
Iron (Fe^{2+})	0.3	0.1 (Max. 1)	50
Nitrate (NO_3^-)(mg/l)	10	50	50
Calcium (mg/l)	75	75	-
Sulphate (SO_4^{2-})(mg/l)	100	25 (Max. 250)	200 (Max. 400)
Chromium (Cr^{6+})(mg/l)	0.05	0.05	-
Manganese (Mn^{2+})(mg/l)	0.2	0.05 (Max. 0.5)	20 (Max. 5000)
Copper (Cu^{2+})(mg/l)	1	0.05 (Max. 1.5)	-
Phosphate (PO_4^{3-})(mg/l)	-		400 (Max. 5000)
Chlorine Residual	0.2-0.25	-	-
Bacteria Count/100ml	10	-	< 1
E. Coli (24hrs)	0	-	-

The pH value of hydrogen ion concentration is a measurement of the acidity or alkalinity (basicity) of water. The pH value of Ajibode ranged from 6.77 to 7.33 and Agbowo ranged from 6.33 to 8.24 (Tables 3 & 4). With the exception of SP08 not meeting the required standards, the values of pH in sampling points SP01 – SP07 and SP09 -SP15, met the required portable water standards of Nigerian Standard (SON), European Union (EU) and WHO. According to Fatoki et al (2002), the pH of a water body is very important in that it may affect the solubility and toxicity of metals in the aquatic system, these pH ranges were therefore used to access the metal toxicities in the wells under consideration. Conductivity is the measurement of the ability of a solution to carry electric current. The determination of electrical conductivity helps in estimating the concentration of electrolytes. Its ability is dependent upon the presence of ions in solution and its measurement is an excellent indicator of the total dissolved solid in matter. The result of electrical conductivity analyzed ranged from 285 to 877 (µs / cm) in Ajibode and ranged between 877 and 2011 (µs / cm) in Agbowo. It has been established that the conductance of water solution increase as temperature rises (Twort and Dickson, 1994). The low conductivity value in SP03 was due to low temperature. It is interesting to note that locations SP08, SP09, SP10, SP11, SP13, SP13, SP14, SP15 (tables 3, 4 and fig. 9) were above the stipulated permissible limit for Nigerian Standard, and 1200 (µs / cm) for World Health Organization (WHO). SP01 – SP07 and SP12 fell within the permissible limit.

Table 6: WHO DRINKING WATER QUALITIES AND THEIR EFFECTS

SUBSTANCES OR CHARACTERISTCS	UNDESIRABLE EFFECT THAT MAY BE PRODUCED	HIGHEST DESIRABLE LEVEL	MAXIMUM PERMISABLE LEVEL
Substances causing discolouration		5 Pt Co	5 Pt Co
Substances causing odour	Odours	Unobjectionable	Unobjectionable
Substances causing tastes	Tastes	Unobjectionable	Unobjectionable
Suspended matter	Turbidity possibly gastrointestinal irritation	5 units	25 units
Total solids	Tastes gastro-intestinal irritation	500mg/L	1500mg/L
pH range	Taste and corrosion	7.0 - 8.5	6.5 - 9.2
Anion detergents	Taste and foaming	0.2mg/L	1.0mg/L
Mineral oil	Taste and odour after chlorination	0.01mg/L	0.3mg/L
Phenolic compounds	Taste, particularly in chlorinated water	0.01mg/L	0.002mg/L
Total hardness	Excessive scale formation	75mg/L	200mg/L
Calcium	Excessive scale formation	75mg/L	200mg/L
Chloride	Taste, corrosion in hot water systems	200mg/l	600mg/L
Copper	A stringent taste, discolouration and corrosion of pipes, fittings and utensils	0.05mg/L	1.5mg/L
Iron	Taste, discolouration, deposits and growth of iron bacteria, turbidity	0.1mg/L	1.0mg/L
Magnesium	Hardness, taste, gastrointestinal irritation in the presence of sulphate	Not more than 30mg/L if there are 25mg/L of sulphate, if there is less sulphate, magnesium up to 150mg/L may be allowed.	
Manganese		0.05mg/L	0.05mg/L
Sulphate		200mg/L	400mg/L
Zinc		5mg/L	15mg/L

SOURCE: WHO (2008)

Turbidity is an expression of certain light scattering and light absorbing properties of the water sample caused by the presence of clay, silt, suspended matter, colloidal particles, plankton and other microorganisms (WHO, 2008). Turbidity can be measured by turbidity and nephelometry. Turbidity of water affects other water quality parameters such as colour, when it is imparted by colloidal particles. It also promotes the microbial proliferation, thus affecting negatively the microbiological quality of water. It also affects the chemical quality of drinking water through the formation of complexes between the turbidity causing humic matter and heavy metals (WHO, 2008). The turbidity results obtained, ranged between 0.77 -118 NTU which was within the permissible limit for Nigerian Standard, European Union (EU) and WHO though three sampling points (SP02, SP09, SP15) proved otherwise. TDS values was significantly different at 2 sampling points, lower at SP03 and SP05, 126.8mg/l and 137.1mg/l and higher at SP15 - 1008mg/l. The values for Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) were within the permissible limit set for drinking water. However, TSS did not vary significantly between the sampling points except in sampling point AJ03. The major determinant of the TDS level in water is

the geochemical characteristics of the ground it comes in contact with, for example granite and silicons sands, and well leached soils have TDS less than 360 mg/l, and the WHO (2008) gave the palatability of drinking water according to its TDS level as less than 500 mg/l excellent level and greater than 1700 mg/l as unacceptable (Table 7). TDS is related to other water quality parameters like hardness, which may occur if the high TDS content is due to the presence of carbonates.

Table 7: TDS level of drinking water for consumer ratings.

Rating	TDS levels (mg/l)
Excellent	<300
Good	300 - 600
Poor	600 - 900
Unacceptable	>1700

Source: WHO, 2008

Hardness is a measure of how much calcium and magnesium is present in water (Olajire and Imeokparia, 2001).In other word, the Total hardness is dependent upon the amount of calcium or magnesium salts or both. Total hardness results obtained, ranged between 77 mg/l -332 mg/l. These values were within the highest desirable level of Standards for Drinking-water considered.

The temperature shows a steady range throughout the sampling points SP01 – SP07 whereas a varying temperature range was recorded at sampling points SP08 – SP15. Bacteria count of the sampling points were recorded to be too numerous to count.

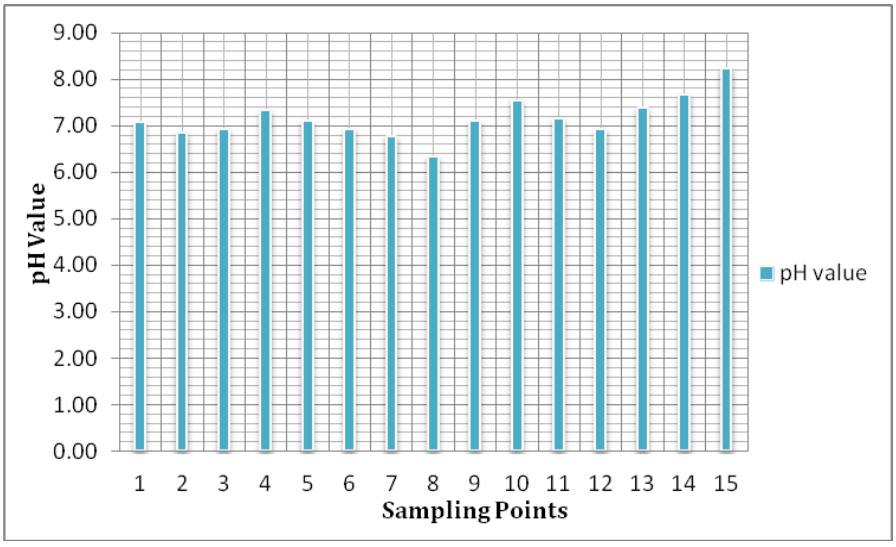

Figure 3: pH value at sampling points

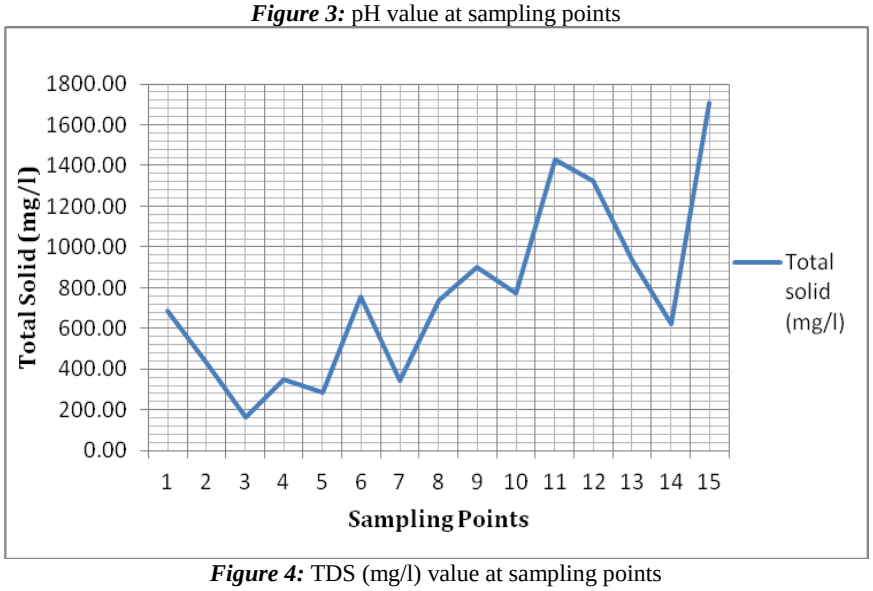

Figure 4: TDS (mg/l) value at sampling points

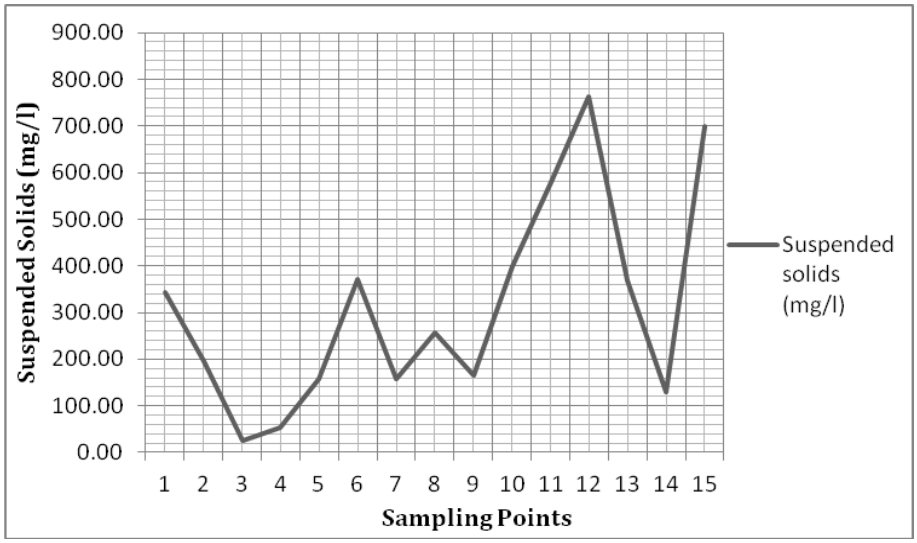

Figure 5: TSS (mg/l) value at sampling points

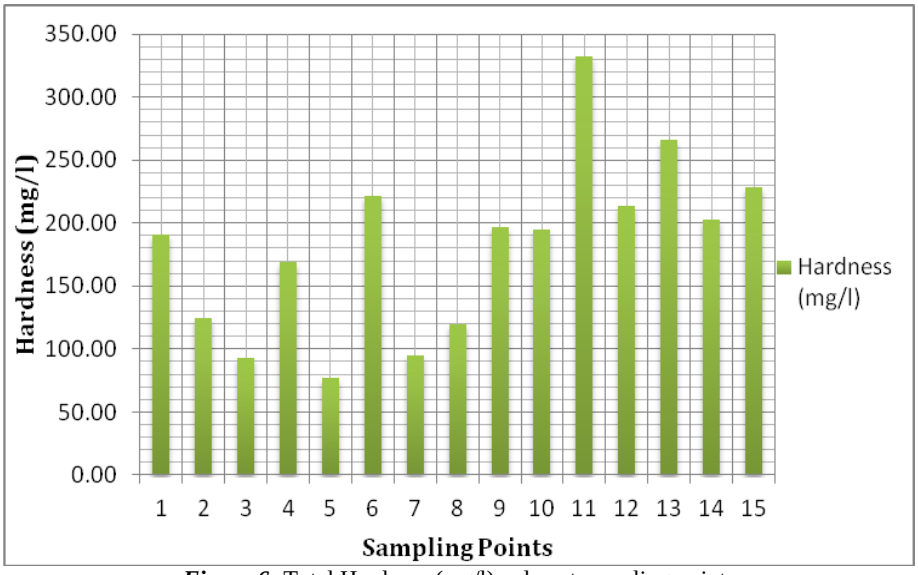

Figure 6: Total Hardness (mg/l) value at sampling points

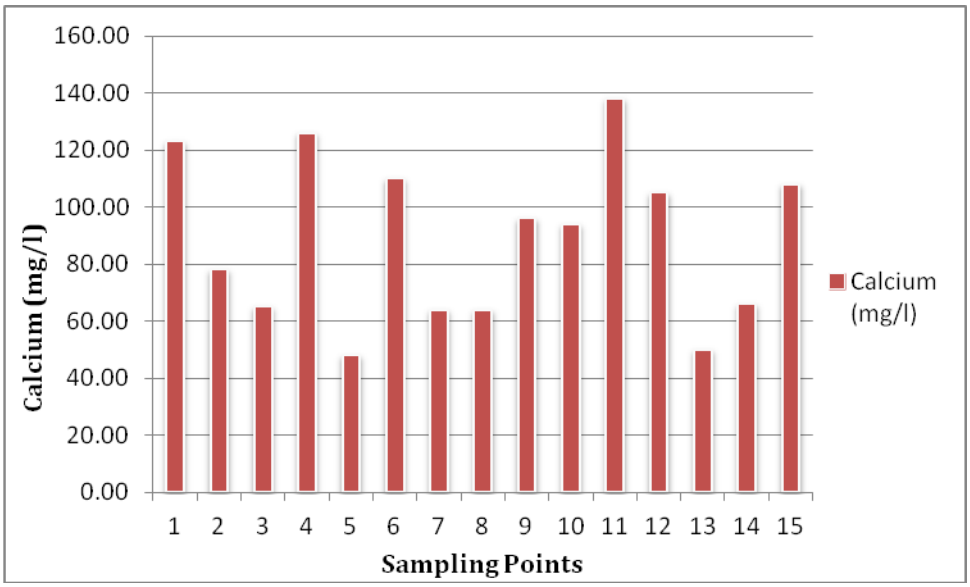

Figure 7: Calcium (mg/l) value at sampling points

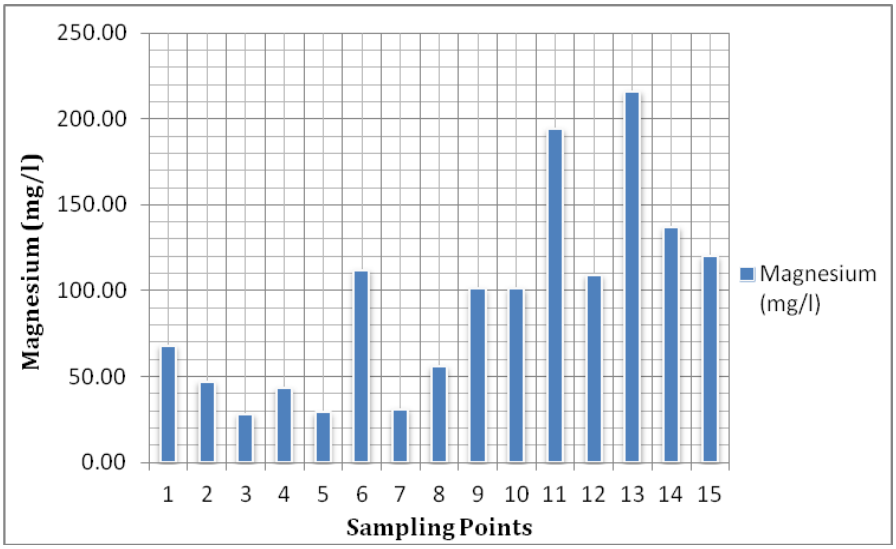

Figure 8: Magnesium (mg/l) value at sampling points

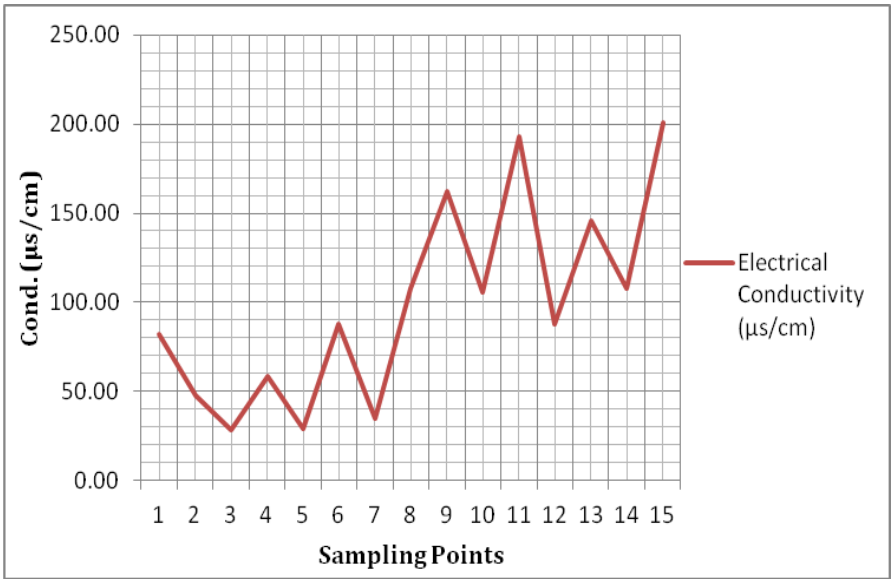

Figure 9: Cond. (µs/cm) value at sampling points

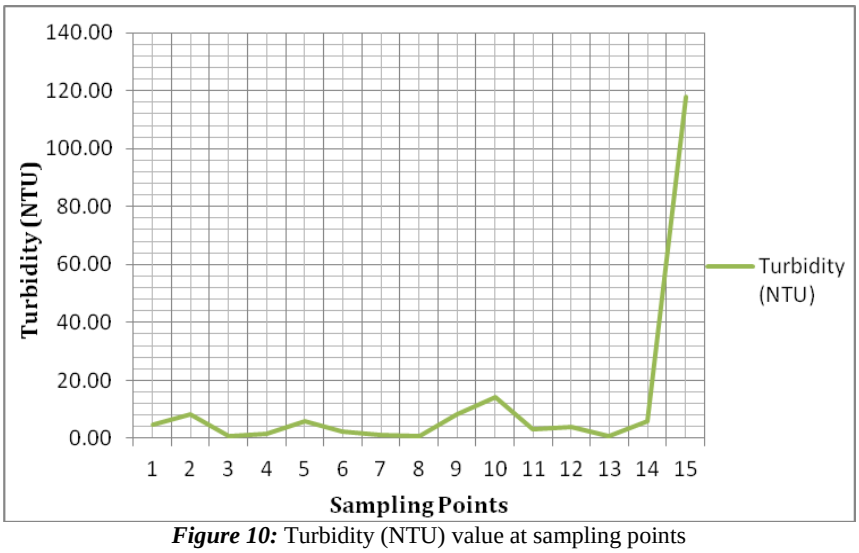

Figure 10: Turbidity (NTU) value at sampling points

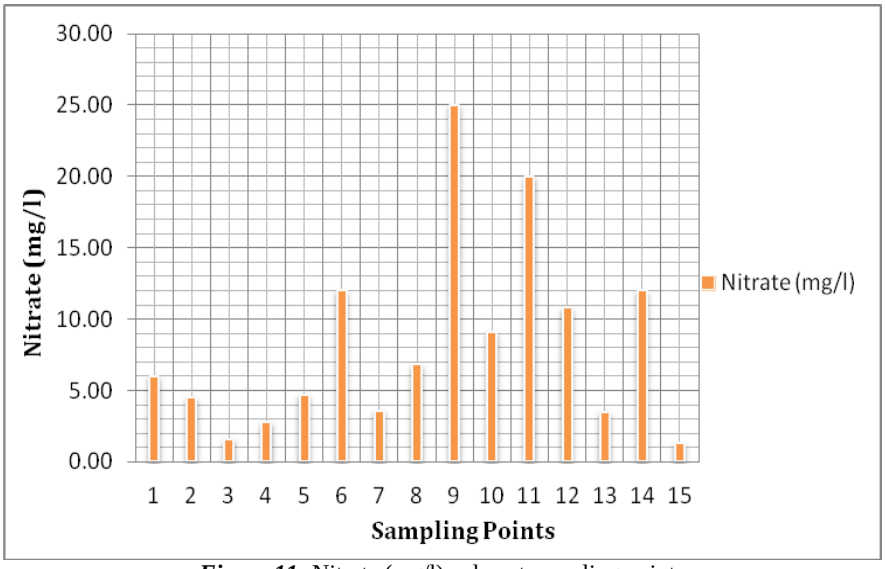

Figure 11: Nitrate (mg/l) value at sampling points

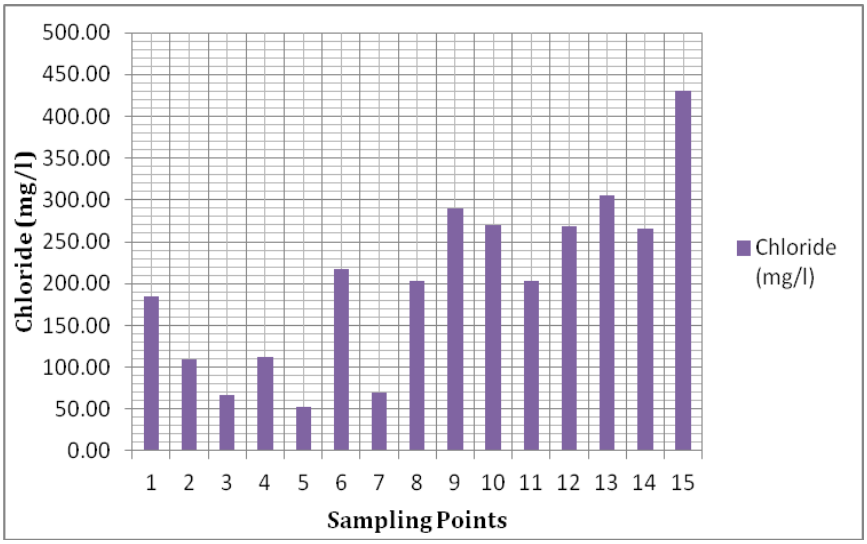

Figure 12: Chloride (mg/l) at sampling points

Sulphate concentrations obtained at these sampling points ranged from 7 mg/l – 95 mg/l which is still within the recommended limit. The Nitrate at all the sampling points range between 1.30 mg/l - 25 mg/l which is low when compared with the guideline level of 50 mg/l (short-term exposure) and 3 mg/l (short-term exposure) WHO *International Standards for Drinking-water* (2008). The Chloride concentration at sampling points SP06, SP02, SP03, SP05, SP06, SP07, SP08 recorded values that indicated a deviation from the recommended level of the Nigerian Drinking Water Standard but acceptable in the WHO *International Standards for Drinking-water* (2008).

Water colour values were not significantly different between the sampling points. Significant variation was however recorded at SP15. Chromium concentrations obtained at the sampling points ranged within 0.01 mg/L – 0.06 mg/L which is still within the recommended limit. Copper concentrations obtained at the sampling points ranged within 0.04 mg/l – 0.29 mg/l, which is still within the recommended limit. WHO guideline value for manganese is 0.4 mg/L which makes the values obtained at the sampling points acceptable.

The phosphate concentrations obtained at the sampling points ranged between 0.09 mg/L – 6.20 mg/L which is still within the recommended limit when compared with the EC drinking water standard of 400 mg/L.

In general, the data revealed that maxima and minima concentrations of the priority physiochemical water quality parameters examined in the 15 water sources were mostly within the target water quality range (TWQR) for domestic use with little exceptions at some points, making these 15 water sources available in the area less potentially health hazardous to inhabitants. The overall implication of this observations, call for sustenance and improved water resources management strategy for the area in order to prevent the deterioration of the water sources quality, which may pose associated health risk and environmental hazards. The following recommendations are made to enhance the quality of the water drawn from this groundwater sampling points and as well protect the public health of the people who depend on it as a source:

(i) The wells from which water is drawn should be covered after use and the surrounding be kept clean to ensure that the water is hygienic for drinking and other purposes.

(ii) Waste management practices should be encouraged when and where appropriate and essential. Adequate solid waste disposal method should be adopted, phasing out open dumpsites to safeguard public health from water borne diseases.

(iii) Increase and continue combined environmental interventions, through public health education by community based health workers, through awareness and sensitization campaigns for improved household and community sanitation

(iv) Regular monitoring of the activities of the community members by the State Environmental Protection Agency and other representatives of the Local government in order to enhance compliance with hygienic requirements and sanitary regulations operating in the state.

(v) The State and Local Government should provide the needed infrastructure for the people living in the community. During the study, it was observed that there were no proper drainage system in place to convey wastewaters from domestic uses at homes and runoffs.

REFERENCES

[1]. Ayoade, J. O. and Oyebande, B. L. (**1983**): 'Water Resources' in: Oguntoyinbo J. S.; Filani M. and Areola O. O. (Editors); A Geography of Nigeria Development (2ed) Heinemann Ibadan, pp 40-56.

[2]. Buchanan (**1983**). Ground Water Quality and Quantity Assessment. J. Ground Water. pp. 193-200.

[3]. Chilton J (**1992**). Women and Water. Waterlines J. 2(110): 2-4.

[4]. Efe, S. T. (**2002a**): Urban Warming in Nigerian cities. The case of Warri metropolis. African Journal of Environmental Studies 2(2) 6p.

[5]. European Union (EU) (**1998**). Drinking Water Standards (EU directive 98/83/ec).

[6]. Fatoki O. S., Lujiza N. and Ogunfowokan A. O. (**2002**): Trace metal pollution in the Umtata River. *Water SA* 28 (2) 183-190.

[7]. Filani M. O. (**1994**): Ibadan Region. *Re-Charles Publication in conjunction with ConnellPulications, Ibadan,271pp*.

[8]. Hofkes A. K. (**1981**). Water for sustainable development in the 21st century and global perspectives. Water Int., 4(16): 20-25.

[9]. Olajire A. A., Imeokparia FE (**2001**). Water Quality Assessment of Osun River: Studies on Inorganic Nutrients. Environmental Monitoring and Assessment. 69(17) 2:2.

[10]. Ojo O. I. (**2002**). Construction and maintenance of Borehole in Anambra State (PTF sponsored project experience) M.Sc Seminar Report University of Ibadan. Department of Agricultural and Environmental Engineering.

[11]. Park J, Park K (**1994**). Textbook of preventive and social medicine. Ms Banarsidas bhanot Publishers, 1167, Prem. Nagar, pp. 468-541.

[12]. Sangodoyin AY (**1987**). Lecture note on Advances hydraulics and water resources Department of Agricultural and Environmental Engineering. University of Ibadan, Ibadan.

[13]. Sangodoyin AY (**1993**). Considerations on Contamination of Groundwater by Waste Disposal System in Nigeria Environmental Technology, 14(10): 957-264

[14]. SON (Standard Organization of Nigeria) (**2007**). Standard Regulation for Drinking Water.

[15]. UNCHS, (Habitat)/UNEP (**1997**): City Experiences and International Support. 2: 67-70.

[16]. World Health Organisation (**2008**). Guidelines for drinking-water quality: incorporating 1st and 2nd addendum: Vol. 1- Recommendations. 3rd edition, Geneva**.**