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Physicochemical and Bacteriological Quality Characterization of Some Selected Wells in Ado-Ekiti, Nigeria

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ABSTRACT: *Groundwater (Wells) is obtained from several well-defined and different water-bearing geological layers or strata. The physical, chemical and bacteriological quality of the water contributed from each of these water-bearing formations and resultant effects of indiscriminate wastes disposal will be dependent on the dissolution of material within the formation. Therefore, water withdrawn from any ground water source will be a composite of these individual aquifers. The water quality was determined by actual sampling and analysis of the completed wells. This study attempted to examine the physicochemical and bacteriological water quality of twenty five selected wells comprising twenty boreholes (deep wells) and five hand dug wells (shallow wells). The twenty five wells cut across the entire Ado Ekiti Metropolitan area. The water samples collected using standard method was promptly taken to water laboratory at the Federal Polytechnic Ado-Ekiti for analysis, physical, chemical and bacteriological tests were carried out. Quality characteristics tested were found to meet WHO's standard and generally acceptable, making it potable for drinking in most situations,thus encouraging the use of groundwater. Possible improvement strategies to groundwater exploitation were highlighted while remedies to poor quality water were suggested.*

Keywords: *bacteriological, physicochemical, quality, wells, Ado-Ekiti*

I. INTRODUCTION

In Ado – Ekiti, Ekiti State, Nigeria, the main source of water available is groundwater, which after undergoing adequate extraction and natural self-purification, is suitable for human consumption. Ground water generally will be considered the most readily available source of water because it can be tapped from below the water table beneath the earth [1]. The quantity and quality of water demand vary among users since water is used for different purposes. There have been an increase in the number of industries, commercial outfits; more hotels and offices are built on regular basis.

Water is in constant use by the residents of Ado-Ekiti for drinking, cooking, washing, recreation, flushing of toilets, landscape maintenance and fire services. Apart from these uses to which available quantity of water is being put, some quantity is used in the management of poultry, piggery, bakeries and artificial habitat for fish farming. Water quality is affected by a wide range of natural and human influences. The need for regular supply of water to meet the water demand of the ever increasing population requires an urgent investigation of the quantity and quality of the groundwater potential in Ado – Ekiti.

Water is essential for life, but it can and does transmit disease across countries in all continents – from the poorest to the wealthiest, the disease carrying capacity of river does not recognize colour, boundary or race. [2]. Due to exposure to agents of faecal contamination, these sources of water are not suitable for potable use, however, with improved technology, the extraction and purification of the naturally occurring water have made water medically safe for human consumption. Incident of diseases and illness are usually on the increase during the dry season. The psychological depressions that usually accompany this menace are not only embarrassing, but the resulting damage to the lives of people is incalculable.

According to [3], water quality refers to the state of physical, chemical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species or to any human need or purpose. A set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to health of ecosystem, safety to human contact and drinking water.

In their own view, [4] disclosed that groundwater can be contaminated by a variety of different sources. They stressed that some of the most common are landfill leachate, chemicals in underground tanks, septic tank effluent, industrial waste lagoons, chemicals disposed through injection wells, oil field brine, crop pesticides and fertilizers, animal feeds lots, and saltwater intrusion. He explained that groundwater quality is evaluated through the assessment of the physical, chemical and biological characteristics.

It is pertinent to note that [5] mentioned that the modern industrial and agricultural activities of the increasing population of man have always been a major source of pollution to groundwater resources by releasing untreated wastes. They were of the opinion that in the quality evaluation of groundwater, it is very important to consider the chemical composition of the water before it is used for domestic consumption. Some contaminants and impurities which usually find their ways into groundwater through recharge from infiltration of rainfall and other sources of recharge are often hazardous to human health.

According to [6] the activities of man had often resulted into environmental pollution and contamination of groundwater. Such activities, he stressed, include indiscriminate location of soak away and pit latrines, poor wastewater disposal methods and refuse dump in rivers. [7] reported that waste component at dump site, chemical impurities, which can either be organic or inorganic substances from industries, fertilizers and pesticides from agriculture usage, suspended and colloidal matter and mineralogical compounds like iron oxide, all find their ways into the groundwater through unsaturated soil.

The consumption of these contaminants and impurities above the measures comparable to the standard recommended by World Health Organization (WHO) guidelines for potable waters would always result to diseases that affect human health. Such diseases include typhoid, cholera, hepatitis, lenteritis, amoebic dysentery, malaria, ascariasis, filariasis, entamoeba, leptospira, Escherichia, coli, salmnella. The survey conducted by WHO in 1976 in the developing countries showed that not lesser than 30,000 people died from water borne diseases, while 80% of the illnesses are attributed to poor quality water [8]. According to the survey report, about 400 million people in the developing countries suffer from gastroenteritis, 200 million suffer from schistosomiasis and 160 million suffer from malaria.

In 1992, WHO reported about 461,783 cases of cholera while about 8072 death were recorded in 58 countries due to this disease [8] [5] reported that more than 50,000 people were affected by water borne diseases in USA between 1948 and 1980 while a total number of illness associated with water borne diseases were put at 150 and 475 respectively. Sequel to this, physical, chemical and bacteriological examination was conducted on both deep and shallow wells in Ado-Ekiti. This study which was aimed at ascertaining the safety of the groundwater for domestic use within the metropolis was carried out by the authors as a results of the following:

i. Considering the spate of indiscriminate disposal of solid and liquid wastes in Nigeria, what effect will these have on groundwater?
ii. Wells are dug at household level by individual property owners, when digging is completed, the water sample is rarely taken to the laboratories for analysis to determine its physicochemical and bacteriological quality before usage is commenced. Thus, its safety for human consumption is not usually ascertained.
iii. Water is drawn from these wells for household usage include drinking without treatment in all the surveyed areas. This practice is not peculiar to the study areas but nearly everywhere across Nigeria.
iv. Use of chemicals (herbicide) and synthetic chemicals for weed control is on the increase in and around the study area. Could this possibly impair the groundwater quality?
v. Wells are dug without approval from government, in order words, there is no regulation for digging of wells in the study area. The location and depth of the well is chosen at the discretion of the property owners and the artisans.

II. METHOD

2.1 Setting

Ado Ekiti is a city in southwest Nigeria (Fig.1), the state capital and headquarters of the Ekiti State. It is also known as Ado. It has a population of 308,621 [9]. The projected population of Ado Ekiti in 2012 as put at 424, 340 by Wikipedia. The people of Ado Ekiti are mainly of the Ekiti sub-ethnic group of the Yoruba. Ado Ekiti (Fig.2) has three tertiary educational institutions namely: Ekiti State University, Afe Babalola University and The Federal Polytechnic Ado Ekiti. It also play host to two local television and radio stations; NTA Ado Ekiti, Ekiti State Television (ESBS), Radio Ekiti and Progress FM Ado Ekiti. Various commercial enterprises operate in Ado Ekiti.

The town lies between the latitude 7^0 33^1 and 7^0 42^1 North of the equator and the longitude 5^0 11^1 and 5^0 20^1 East on a low-land surrounded by several isolated hills and inselbergs, [10]. Geologically, the region lies entirely within the pre-Cambrian basement complex rock group, which underlies much of Ekiti State [11]. The temperature of this area is almost uniform throughout the year, with little deviation from the mean annual temperature of 27^0 C. February and March are the hottest 28^0 C and 29^0 C respectively, while June with temperature of 25^0 C is the coolest [12]. The mean annual rainfall is 1,367mm with a low co-efficient variation of about 10%. Rainfall is highly seasonal with well-marked wet and dry season. The wet season lasts from April to October, with a break in August.

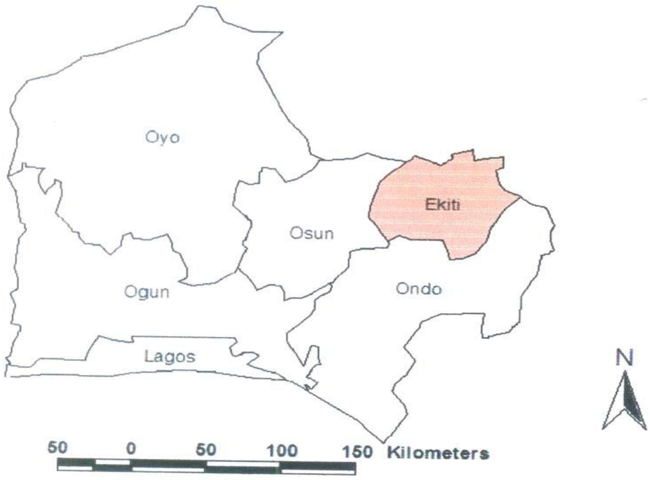

Figure 1: Map of South West Nigeria showing Ekiti State (Source: [13])

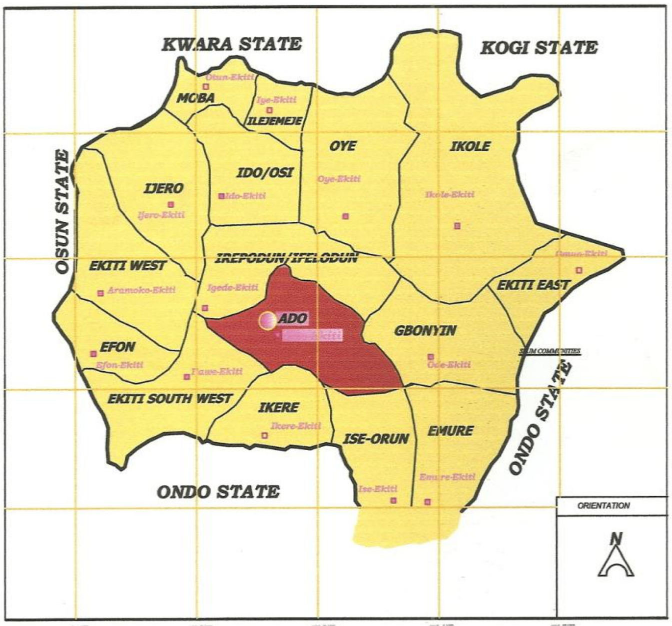

Figure 2: Map of Ekiti State showing Ado-Ekiti [13]

2.2 Water sample collection and analysis procedure

Water samples were collected randomly from twenty boreholes and five hand-dug wells located in twenty-five different areas of Ado-Ekiti. The water samples were collected between 6.00am and 9.00am. The collection of samples was done in three days. Two samples were collected from each of the boreholes and hand-dug wells using sterile plastic container of 2 litres capacity which were thoroughly washed with 5% HNO_3 and left to dry for 24 hours before the samples were collected. The collected samples were taken to the laboratory within 2 hours of collection for physical, chemical and bacteriological analysis. The samples were coded for easy identification using $BH_{1\text{-}20}$ for boreholes and $WL_{1\text{-}5}$ for hand-dug wells.

2.3 Physical analysis

The parameters examined in physical analysis included; temperature, colour, odour, turbidity, total solid, suspended solids, dissolved solid electrical conductivity. Details of each parameter are given below;

2.3.1 Temperature

Thermometer was dipped into the collected sample and left in position until the mercury thread reaches a constant reading on the calibration. The value at the constant level was then recorded.

2.3.2 Colour

The raw water sample to be examined was put in the comparator tube at the left compartment; colour disc was selected and fitted into the compartment, rotated until a colour match was obtained. The corresponding value on the colour compartment was recorded.

2.3.3 Odour
This was carried out by a successive 50ml of distilled water to re-dilute a given measure of raw water sample. The ratio or proportion of raw water sample to distilled water used up at a known ml of raw water when odour is no longer detected or perceived is the odour number of the sample examined.

2.3.4 Turbidity
A DRT 100B turbidimeter was calibrated according to manufacturer's instruction by putting 0.02 N.T.U. reference standard prepared solution into the optical well covered completely with light shield till the values were seen. It was immediately replaced by the raw water sample with a specific range determined by the level of impurities detectable from dispersed light in the meter. The value of turbidity of the sample examined is then recorded.

2.3.5 Total solid (mg/l)
50ml of water sample was measured previously into weighed sterilized evaporating dish and evaporated to dryness in an oven at 121^{0}C for 30 minutes. The residue was cooled in a desiccator and weighed. The total solid of the raw water sample at 121^{0}C in mg/l of 50ml is obtained through (1).

$$\text{Total Solid} = \frac{W_2 - W_1}{V} \qquad (1)$$

where, W_1 = Weight of Evaporating dish
W_2 = Weight of Evaporating dish + dry residue
V = Volume in ml of sample.

2.3.6 Suspended solid (mg/l)
50ml of water sample was measured with pipette and filtered with already weighed filter paper Watchman No 50, oven-dried, the residue on the filter paper was re-weighed using a mettler balance. The suspended solid in 50mg/l in the raw water samples were computed and recorded using the (2).

$$\text{Suspended solid in 50mg/l} = \frac{X_2 - X_1}{V} \qquad (2)$$

where, X_2 = Weight of the filter + residue
X_1 = Weight of the filter paper
V = Volume of sample used

2.3.7 Dissolved solid
A clean evaporating dish was dried in an oven at 105^{0}C for 30 minutes, cooled the dish in dessicator for 10minutes. The dish was weighed "A" on analytical balance and recorded in gm. 50ml of raw water sample for quality examination was pipette into the dish and placed in the oven at 105^{0}C to dryness. The dish was weighed as "B" after being allowed to cool for 10minutes in the dessicator.
The total dissolved solids were calculated using the expression (3),

$$\text{50mg/l total dissolved solids at } 105^0\text{C} = \left(\frac{(B-A) x\ 100\ x\ 1000}{50ml\ of\ sample\ used}\right) \text{mg/l} \qquad (3)$$

2.3.8 Dissolved oxygen
Dissolved oxygen content of the water samples tested were carried out using a polar graphic digital oxygen meter. The electrode was calibrated with 10% sodium sulphite solution, lowered into the solution 25cm depth and stirred for 30minutes for calibration before dipping the electrode into sample. Thereafter, it was allowed to stabilize in the sample for 20 seconds and concentration of oxygen content is recorded from the meter in parts per million (ppm) of ml of sample determined.

2.4 Chemical analysis
All the samples were analyzed in duplicate. The following parameters: pH, alkalinity, chloride, carbonate, bi-carbonate alkalinity, calcium, magnesium were determined by titrimetry method. Sodium and potassium ions were determined by atomic absorption Spectrophotometer and total hardness test was carried out by LOVIBOND TEST KIT using total hardness tablets using test sample range (0 – 500)mg/l as $CaCO_3$ of sample.

2.4.1 Alkalinity and acidity
Two drops of sodium thiosulphate and four drops of hydrogen peroxide solution was added to 25ml of the water sample in a volumetric flask, after which the mixture was boiled for 5 minutes. The mixture was allowed to cool, two drops of phenolphthalein indicator added and the mixture titrated against 1m H_2SO_4 to a colourless end point. To this same mixture was then added two drops of methy (orange indicator and tilration continued to a final end point).

2.4.2. Acidity
This was similarly carried out except that indicator used was sodium bicarbonate and phenolphthalein. Indicators were added to the samples until end point values were then obtained.
2.4.3. Chloride
100ml of water sample was filtered and pipette into a conical flask. Two drops of sodium hydroxide buffer solution was added as pH modifier (pH 7-10). 1ml of potassium chromate solution was added as indicator and sample titrated with standardized silver nitrate solution to a pinkish yellow end point.
2.4.4. Iron
To 20ml of the water sample, poured in lovibond tube contained in the Comparator Apparatus test kit, one iron tablet was crushed into powder and added to the sample agitated and allowed to settle and mixed up completely for 10 minutes after which their iron concentrations were read off directly by means of a BDH colour Lovibond Colour comparator fitted with iron test disc until respective colour developed and recorded.

2.4.5. Total hardness (mg/l)
This was similarly carried out using LOVIBOND TEST KIT. 50ml of each sample (test range) was poured into graduated Lovibond tube one tablet, crushed into powdered was added to the sample at one time each until colour changed from plum blue to blue colour. Then, concentration of the hardness is 50ml of sample is obtained by multiplying the number of tablets used until the blue colouration appeared, e.g 40 x 20, where 20 is the distribution factor (DF). That gave the actual concentration of mg/l hardness range and their corresponding classification in terms of level contained in the water samples and recorded.

2.4.6. Potassium, sodium and lead
These were carried out using Atomic absorption spectrometer (Bulk Scientific Model 200A).
Procedures: 100ml of each of the samples was digested with 1:1 mixture of HNO_3 and H_2SO_4. It was then boiled and evaporated to dryness.. The metals in the sample are in soluble form. The mixture obtained was then diluted with deionised water and made up to 100ml in standard volumetric flask.
Subsequently, the elements (K, Na and Pb) determined were also prepared in deionized water. The absorbance of the sample and standard were determined using cathode lamp and appropriate wavelength.
The concentration of Ka, Na and Pb metallic ions were obtained using the expression eqn. (4);

$$\text{Concentration} = \frac{PPM\ of\ Sample\ X\ Dilution\ factor}{Ml\ of\ Sample\ used} \quad (4)$$

III. RESULTS AND DISCUSSIONS

Groundwater quality is being adversely affected by a wide range of volatile organic compounds and inorganic chemicals. Many chemicals contaminating groundwater are man-made and careless disposal of waste products. Water quality is dependent on physical, chemical and biological characteristics of the water samples with reference to their intended use. The results of laboratory examination on samples from 20 boreholes (BH_{1-20}) and 5 hand-dug wells (WL_{1-5}) were compared with World Health Standard (WHO's Standard) and The Nigerian Standard for Drinking Water Quality (NSDWQ). The results are presented in Table 1, 2 and 3.

Table 1: Physicochemical and Bacteriological parameters of the bore hole water samples

Parameters	BH_1	BH_2	BH_3	BH_4	BH_5	BH_6	BH_7	BH_8	BH_9	BH_{10}
pH	6.8	6.5	6.2	6.4	6.2	6.4	6.5	6.5	6.8	5.5
Calcium (mg/L)	56	54.5	51.0	48.9	57.5	48.0	40.8	46.2	52.9	36.5
Magnesium (mg/L)	16.5	10.5	34.5	15.5	24.5	29.8	14.5	34.9	20.5	25.5
Chloride (mg/L)	35.2	21.4	12.9	10.95	15.88	12.0	9.05	7.5	10.2	9.50
Iron	0.1	0.1	0.1	1.0	0.01	0.1	0.1	0.1	1.0	1.5
Acidity	10.2	9.5	4.5	7.5	16.0	8.5	12.0	9.5	6.2	15.0
Carbonate Alkalinity (mg/L)	0.0	0.00	0.00	0.00	0.0	0.0	0.0	0.00	0.00	0.50
Bi-Carbonate Alkalinity (mg/L)	10.2	9.50	12.3	15.0	4.6	13.9	12.0	14.2	6.05	20.4
Total Hardness (mg/L)	60	60	60	80	80	60	60	60	100	180
Lead (mg/L)	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Sodium (mg/L)	0.2	0.8	0.4	1.20	0.8	0.4	0.7	0.3	0.5	0.7
Potassium (mg/L)	2.50	2.80	2.00	1.60	1.20	1.25	2.50	2.00	1.26	0.65
Dissolved Oxygen (ppm)	0.50	04.5	0.60	0.55	0.50	0.60	0.45	0.50	0.65	0.30
Turbidity (N.T.U)	3.50	5.00	4.25	3.05	2.55	2.75	4.33	6.82	5.90	15.5
Total Solid (mg/L)	80.6	130	110	141.0	30.5	183.6	62.5	210	98.5	100.5
Suspended Solid (mg/L)	42.5	37.0	22.5	88.8	6.5	92.0	25.0	42.0	39.8	60.5
Dissolved Solid (mg/L)	38.1	93.0	87.5	69.0	28.5	63.6	37.5	16.8	58.7	40.0
Electrical Conductivity µ S/cm (25^0C)	192.0	140.0	99.5	88.8	79.0	92.0	71.5	70.5	95.0	162.0
i. E.Coli	NILL	NILL	NILL	NILL	NILL	NILL	NILL	NILL	NILL	01
ii. Faecal Coliforms Counts	NILL	NILL	NILL	NILL	NILL	NILL	04	NILL	NILL	02

c.f.u/100ml sample (x10^1)										

Table 2: Physicochemical and Bacteriological parameters of the bore hole water samples

Parameters	BH_{11}	BH_{12}	BH_{13}	BH_{14}	BH_{15}	BH_{16}	BH_{17}	BH_{18}	BH_{19}	BH_{20}
pH	6.8	7.4	5.2	6.5	5.4	7.8	6.0	6.4	5.5	7.4
Calcium (mg/L)	48.5	92.0	54.5	32.0	36	40	36	38	40.5	50.5
Magnesium (mg/L)	30.2	28.8	15.5	20.5	16.0	20.0	25.5	18.8	19.2	20.4
Chloride (mg/L)	14.0	16.2	14.2	10.9	14.5	12.5	14.0	5.04	16.8	8.05
Iron	1.5	2.0	3.0	1.5	2.0	1.0	1.5	1.0	0.1	1.5
Acidity	12.5	10.6	15.9	20.7	15.0	12.0	18.0	9.5	17.52	11.9
Carbonate Alkalinity (mg/L)	1.00	6.00	2.00	0.00	0.0	0.00	0.00	0.00	0.00	0.10
Bi-Carbonate Alkalinity (mg/L)	18.2	32.5	16.5	12.4	9.5	12.0	10.5	4.9	12.0	7.4
Total Hardness (mg/L)	80	320	120	80	60	40	180	100	80	60
Lead (mg/L)	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Sodium (mg/L)	3.0	6.0	4.0	0.8	0.3	0.6	0.8	0.3	0.4	3.0
Potassium (mg/L)	0.65	1.65	2.50	6.0	13.0	2.50	1.65	0.90	4.20	1.50
Dissolved Oxygen (ppm)	0.35	0.25	0.35	0.25	0.45	0.56	0.45	0.50	0.55	0.35
Turbidity (N.T.U)	4.55	38.42	25.75	15.6	7.00	4.20	10.22	6.45	4.50	15.50
Total Solid (mg/L)	180	192.5	95.5	75.4	188	72.6	163.2	80.2	60.5	93.6
Suspended Solid (mg/L)	45.0	39.5	24.9	35.4	26.0	32.0	42.5	43.5	31.7	28.2
Dissolved Solid (mg/L)	135.0	153.0	70.6	40	162	40.6	120.7	36.7	28.8	65.4
Electrical Conductivity µ S/cm (25^{0}C)	105	172.5	195.0	126.0	77.5	100.5	120	96.0	95.4	100.2
i. E.Coli	NILL	01	04	NILL	NILL	NILL	NILL	NILL	01	03
ii. Faecal Coliforms Counts c.f.u/100ml sample (x10^1)	01	02	01	NILL	NILL	NILL	02	01	NILL	NILL

Table3: Physicochemical and Bacteriological parameters of the well water samples

PARAMETERS	WL_1	WL_2	WL_3	WL_4	WL_5	WL
pH	5.5	6.0	6.5	7.5	6.8	5.5
CALCIUM (mg/L)	48	48.8	142.0	75.9	120.0	48
MAGNESIUM (mg/L)	15.5	20.2	54.5	30.2	48.8	15.5
CHLORIDE (mg/L)	10.7	4.5	16.2	120.4	72.0	10.7
IRON	0.1	1.5	1.5	2.5	1.0	0.1
ACIDITY	12.0	14.6	22.0	13.7	16.2	12.0
CARBONATE ALKALINITY (mg/L)	0.00	0.00	1.10	0.20	0.00	0.00
BI-CARBONATE ALKALINITY (mg/L)	10.9	15.99	20.5	41.05	25.5	10.9
TOTAL HARDNESS (mg/L)	60	120	60	100	120	60
LEAD (mg/L)	N.D	N.D	N.D	0.01	N.D	N.D
SODIUM (mg/L)	0.4	3.0	4.0	7.0	3.0	0.4
POTASSIUM (mg/L)	2.50	3.00	12.5	7.25	8.20	2.50
DISSOLVED OXYGEN (ppm)	0.55	0.40	0.35	0.30	0.40	0.55
TURBIDITY (N.T.U)	4.77	16.05	17.05	20.15	15.22	4.77
TOTAL SOLID (mg/L)	72.5	165.5	92.5	210.0	128.4	72.5
SUSPENDED SOLID (mg/L)	39.2	35.0	35.2	42.5	38.9	39.2
DISSOLVED SOLID (mg/L)	33.3	80.5	57.3	167.5	128.0	33.3
ELECTRICAL CONDUCTIVITY µ S/cm (25^{0}C)	92.9	102.5	99.5	105.5	195.9	92.9
i. E.Coli	02	NILL	NILL	NILL	02	02
ii. Faecal Coliforms Counts c.f.u/100ml sample (x10^1)	NILL	NILL	01	4	1	NILL

The temperature of borehole ranges between 30 ^{0}C and 32 ^{0}C, while that of the hand dug wells ranges between 27 ^{0}C and 29 ^{0}C. The temperature range observed in this study will discourage rate of chemical and biological reactions, solubility of gases in the water which could impact negatively on the taste and odour of the water at a high temperature [14]**.**

The pH of the boreholes sampled were found to be slightly acidic with pH values ranging between 5.2 and 6.8 with few exceptions like borehole sited around Olukayode stadium in Kajola, Moferere in Ajilosun, and Erinfun along Polytechnic road. The pH of the samples from the hand-dug wells was also found to be acidic with pH ranging between 5.5 and 6.5, except the well sited around Iremo Street in Odo-Ado area, which is slightly alkaline in nature with pH of 7.5. This is lower than pH of 5.9 – 7.45 obtained by [15]. The pH values of the samples from the boreholes and hand dug well indicate the presence of bicarbonates and carbonic acid in the study area. Acidity is caused by high concentration of hydrogen ions, and since the water from most of the boreholes and hand dug wells are slightly acid, application of potassium aluminium sulphate and ferrous sulphate would be highly effective in treating the water to improve the pH to drinking standard. The desirable pH for drinking water is 7.0 – 8.5.

The turbidity of the samples from the boreholes in the study area fall within the standard allowable limits except samples from boreholes at Oluyemi Kayode stadium in Kajola and Mary Immaculate Grammar School area which have high values of 38.42 and 25.75 respectively. Other boreholes which were found to be slightly turbid include; First Bank (Federal Poly.), Opopogbooro,Adehun, Oke Oniyo, Covenant, Moferere, Olujoda, and Igirigiri, with values varying between 5.9 and 15.5. The high values of the samples from Olukayo Stadium in Kajola and Mary Immaculate Grammar School indicate the presence of organic materials and suspended colloidal matter. The contaminants could be removed by either settling or centrifuging. Other methods that could be applied include aeration and adsorption. In the aeration process, water containing organic chemicals is mixed with air in a special chamber or tower which is filled with packing material that disperses the water to enhance air contact. The aeration tower contains beds of materials such as 6.4 to 51mm metal, ceramic or plastic spheres or other types of materials. Water is introduced across the top of the bed and trickles downward through the bed materials. At the same time, air is passed upward through the bed, removing contaminants from the water.

The dissolved solids are a measure of total inorganic substances dissolved in water. In the quality evaluation, the total dissolved solids of most of the boreholes in the study area were found to be within reasonable allowable limit recommended. However, samples from boreholes at first entrance to housing estate, Okeila, Onala area along Tinuola School, Doctors' quarters, Fajuyi, Oluyemi Kayode Stadium in Kajola, Mary Immaculate Grammar School, Covenant Community in Ajebamidele off Ikere Road, and Doctor Makinde's Clinic, Moferere off Ajilosun have relatively high values of total dissolved solids which may cause gastrointestinal irritation and laxative effect in human. The dissolved solids can be removed by evaporation.

The Total Dissolved Solids (TDS) represents the amount of inorganic substances present in water. It shows the general nature of water quality or salinity (Olajide and Imeokparia, 2011). The TDS in the samples were found to be within reasonable and allowable limits recommended by the WHO with exemption of samples from borehole at Oluyemi Kayode Stadium in Kajola, Ado-Ekiti and covenant community in Ajebamidele with values of 153mg/L and 162mg/L respectively. However, the TDS were found to be higher that of [16] who conducted a similar study in Aba South, Abia State Nigeria.

The electrical conductivity in all the samples ranged between 70.5 to 195 µs/cm. Generally, the electrical conductivity is affected by the geology of the area through which the water flows. It is a function of magnesium, calcium, sodium and sulphates in the water [17]. The salinity of the observed groundwater is at disparity with that reported by [16] though it falls within limits approved for safe drinking water.

3.1 Chemical Characteristics

The values of calcium which is an agent of hardness, was found to range between 32mg/L and 120mg/L while magnesium which is another agent of hardness was found to range between 12.9mg/L and 43.5mg/L. The values are within tolerable limits stipulated by WHO's standard. The concentration of chloride ions in the water samples range between 4.5 and 35.2 which fall within tolerable limit of the WHO's standard for drinking water. High concentration of chloride ions may results in an objectionably salty taste [18]. The level of chloride observed in this study is not in similar to that 11 - 22 mg/l and 2.5 – 24.0mg/l reported by [19], [16] respectively. The high level of chloride may be an indication of pollution from domestic waste. The values of hardness obtained range between 60mg/L and 320mg/L. The hardness level can be treated by liming and hydrated soda precipitation. The concentration of Iron (Fe) was found to be slightly high in most samples from the boreholes when compared with the WHO's staandard with values ranging between 0.1 and 3.0. The iron pollution has resulted from dissolved iron from the overlaying laterite layer as a result of recharge water percolating through it. This reduction process has arisen as a result of localized chemical condition of low pH and negative electrical conductivity

There were traces of contaminants by pathogenic organisms in some of the water samples. The presence of *Escherichia coli* and *Coliform* bacteria were noticed in samples from boreholes at Oluyemi Kayode Stadium in Kajola, Mary Immaculate Grammar School and Erinfun, along Polytechnic Road as well as hand-dug well at Fabian Avenue, NTA Road, Iremo Street, Odo-Ado and Irewolede Estate, Ilawe Road.

The results of this study suggested that the borehole and hand dug well water bady were generally contaminated. Presence of *Escherichia coli* in some of the samples shows pollution of the water by human activities. In a similar studies conducted in Aba Metropolis, *Escherichia coli*, a total coliform level of 1.5 to 3.9 x 10^2 cfu/ml was recorded [20].

Generally speaking, the results of chemical analysis showed that the boreholes and hand-dug wells in the study area is chemically suitable for domestic purposes and in line with WHO's and NSDWQ standard. Although most of the water is suitable for use for domestic cores, and for drinking in the natural state, there is need to treat some of the water that show traces of contamination and presence of *Escherichia* and *Coliform* bacteria.

IV. CONCLUSIONS AND RECOMMENDATIONS

1. The pH of the water samples from Adehun, Covenant Community in Ajebamidele, Mary Immaculate and Erifin along Polytechnic road was slightly acidic with pH values ranging between 5.2 and 5.5. Water samples from Oluyemi Kayode Stadium in Kajola, Moferere in Ajilosun, and Igirigiri along Local Government area, were slightly alkaline with pH values ranging between 7.4 and 7.8. Apart from these areas, water samples from all other areas were found to be within reasonable allowable limit recommended by WHO's standard.
2. The total dissolved solids were found to be within reasonable allowable limit recommended by WHO's standard.
3. Total hardness of water samples from the study area ranged between 60 – 320mg/L which was found to be within the limits of 0 – 500mg/L specified by WHO's standard.
4. The concentration of dissolved oxygen varies with the source, location and depth of the boreholes.
5. Traces of faecal coliform were noticed in water samples from Oluyemi Kayode Stadium in Kajola, Mary Immaculate, Olujoda along Ikere Road, Pathfinder and Adehun along Opopogboro. Other biological and bacteriological parameter concentrations in the water samples from the remaining parts of the study area were found to be satisfactory by comparison with recommended standard by WHO. The quality of groundwater in Ado-Ekiti is good with a few exceptions.
6. It is recommended that regular laboratory tests should be conducted on water samples from the different water sources to ensure that the quality conform with the required standard by WHO's and NSDWQ

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