Physicochemical Assessment of Groundwater Quality from Hand Dug Wells and Boreholes of Part of Mokola-Eleyele, Ibadan Metropolis, Southwest Nigeria

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Abstract— *Water is the second most important basic need of man after oxygen which is the first. The quality of life in villages and cities depends on the regular supply of pure and unpolluted fresh water. The quality of water bodies depends on their physicochemical and microbial characteristics. The hand-dug wells and boreholes are charactacterised as groundwater under this study. Sampling was done on 21 points containing wells and bore holes within part of Mokola-Eleyele in order to assess their physiochemical contents. The sample was collected during September 2018 - February 2019. Laboratory analysis was carried out on them. The physical and chemical contents observed are; pH, total dissolved solids (TDS), Calcium (Ca^{2+}), magnesium (Mg^{2+}), Chloride (Cl^-), Sulphate (SO_4^+), Nitrate ($NO3^+$) and iron content (Fe^{2+}) were analyzed for each water sample collected. The values of physical and chemical contents were compared with the standard values set by the Standard Organization of Nigeria (SON) and the results were within their safe limits. The t-test analysis carried out showed the correlation between chemical contents at 90%, 95% and 99% confidence level, the results shows that the significant differences exist for the parameters. It can be concluded that the qualities of both hand dug wells and boreholes water samples were suitable for human consumption*

Keywords— ***Groundwater, Physicochemical, unpolluted, quality, parameters, Regulation standard***

I. INTRODUCTION

Adequate water supply is an essential element in the list of infrastructures of any developing area. Ibadan being an urban area provides a good example of a region where industrial and social developments are being retarded by limited water supplies. With population of about 2.5 million (long term water supply data, 1979) the average water need of a person in Ibadan is about 50 gallon/head/day (WHO 1983), but daily supply of water per person by Oyo state water corporation is 28.0 gallon/head/day, 1985). Therefore inability of the Oyo state water corporation (OSWC) to adequately supply water to the entire population in the study area calls for the need to accelerate planned for groundwater. People in urban areas especially in the North Western part of Ibadan city, which is the local government area in which the study area falls into, rely mostly on shallow dug wells for their domestic water needs.

Groundwater is being one of the earth's most widely distributed and most important natural resources and it exists wherever water penetrates the subsurface soil and where the formations beneath the surface are porous and permeable enough to transmit this water to the zone of saturation. Groundwater becomes useable natural resources when enough water can be tapped from this zone of saturation through wells or boreholes, springs or stream. Many investigations had been carried out on water quality in Nigeria, and these are limited to local scales and consider as few in number by chemical constituents (Ajibade et al., 2018). A survey was carried out on groundwater and tap water quality determined from different sources in southern Nigeria (Asubiojo et al, 1997). Nitrate-NO3 of up to 124 mg/l, nitrite-NO2 of up to 1.2 mg/l in concentration in weathered basement rocks of south-west Nigeria from sample of shallow groundwater from dug wells was reported by (Malomo et al., 1990). Scale formation may be caused by too much alkalinity values and the water may also have a clearly flat, and may cause irritating taste (Orewole et al., 2007). The essential elements required much by the human body are calcium (Ca) and magnesium (Mg) as calcium is used in teeth and bone formation and also plays a crucial role in nerves and

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muscles draw out, and good to make it become smaller and for blood clotting (Frantisek, 2003).

However, the major contributors to water hardness are calcium and magnesium while calcium is crucial for strong teeth and bones. Trace metals in groundwater are chemical elements that dissolved in water in quantity of minute, and in concentration of less than 1 mg of trace metal per one liter of water (United State Geological Survey, 1993). Drinking water that was contaminated by diseases making the microorganisms (i.e. pathogens) continues to exist and globally recognised and this become a severe threat to human health. (Hering, 2008). The primary standard parameter with no health implication is pH (Standards Organisation of Nigeria, 2007). Gastrointestinal disorder is the health implication of high concentration of copper (Cu) while cancer is that of chromium (Cr) (Standards Organisation of Nigeria, 2007).

Potassium (K) from 1-3mg/l has no health effect in drinking water standards (Nkono *et al*, 1998). The demand for water in the study area has been on the increase as a result of urban and industrial growth. Despite the fact that the quality of water being supply by the state Water Corporation is less compared to the WHO standard, it is also irregular, erratic and sometimes with a lot of impurities, thus groundwater now provides an alternative means of getting portable water in the area of study. These facts have therefore help to unveil the importance of this study as enormous and immeasurable. Therefore, this study assesses the physicochemical parameters of groundwater quality from hand-dug wells and boreholes of part of Mokola-Eleyele Axis and domestic uses and its suitability for domestic use.

II. MATERIALS AND METHODS

2.1 The Study Area

Mokola-Eleyele is located in part of Ibadan North and North West Local Government of Oyo State. It is lying between latitude 7° 25′ 24″ to 7° 26′ 09″′N and 4° 22′ 28″ to 4° 23′ 13″E. The area is accessible through major and minor roads. Collective amenities such as shops, markets, hospitals, schools, transport networks are readily available. The area of study was within the rock basement complex comprising; gneises, migmatite, quartzites and schists and older granites as well as quartzites southwesterns Nigeria within which Ibadan lies (Oyawoye, 1970; Rahman, 1976; Elueze, 1982). The rock in the study area serves as good aquifers because of the existence of secondary porosity and permeability which take place as a result of fractures and extreme degree of weathering in the study area.

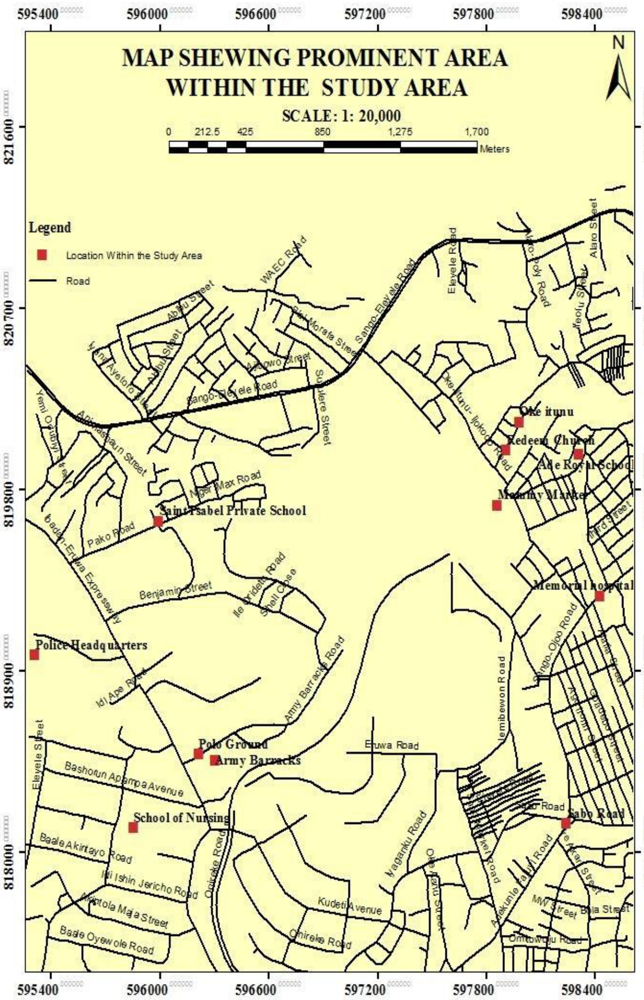

Fig. 1: Study Area Map

2.2 Sample Collection

The total of twenty-one water samples were collected in a random manner, 13 from hand-dug wells and 8 from boreholes within the study area and was collected into a screw capped polyethylene bottles of 75cl capacity. All the samples collected were labeled with their locations and source. Coordinates of sample points for the hand dug wells and boreholes were determined (table 1). Sampling was carried out without adding any preservatives in bottles

Table 1: showing sample locations, groundwater types and their coordinate (x, y) for the study.

Sample Location	Groundwater Type	Easting	Northing
Police Headquarters	Hand-dug well	595495.473	818993.115
Army Barrack	Hand-dug well	596324.814	818404.818
Army Barrack	Hand-dug well	596268.690	818292.570

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Mummy Market	Hand-dug well	597828.935	819605.870
Mummy Market	Hand-dug well	598014.144	819706.893
Oke Itunu	Hand-dug well	597823.323	820183.947
Ade Royal	Hand-dug well	598366.349	820004.914
Redeemed Christian Church	Hand-dug well	597823.323	819998.738
Sabo Road	Hand-dug well	598277.927	818112.974
Saint Isabel Private School	Hand-dug well	596044.195	819628.320
Memorial Hospital	Hand-dug well	598457.523	819229.840
School of Nursing	Hand-dug well	595915.110	818152.261
Polo Ground	Hand-dug well	596291.140	818606.864
Police Headquarters	Borehole	595372.083	818984.889
Army Barrack	Borehole	596235.016	818505.841
Mummy Market	Borehole	597761.587	819746.180
Oke Itunu	Borehole	598002.919	820094.148
Ade Royal	Borehole	598234.733	819996.688
Saint Isabel Private School	Borehole	595982.458	819695.668
Memorial Hospital	Borehole	598350.888	819302.801
Polo Ground	Borehole	596145.218	818533.903

2.3 Analytical Instruments

2.3.1 Onsite Field Analysis

Site analysis was carried out on the field for pH, conductivity and turbidity as at when the sample was taken using American Public Health Organization (APHA) standard methods and protocols and American Society for Testing and materials (ASTMs) using different calibrated standard instruments. The pH of the water samples was measured by using a pH meter (model HI 98130 HANNA Mauritius, iramac sdn, Bhd.). However, before measurements were taken, three standard solutions (ph 4.0, 7.0, and 10.0) were used to calibrate the pH meter. After submerging the pH probe in the water sample and leave for some minutes to obtain accurate reading, then the value for each water sample was taken.

Conductivity meter (model HI 98130 HANNA Mauritius, iramac sdn, Bhd.) was used to determine the Conductivity of the water samples. Standard solution was used to calibrate the probe a known conductivity. Moreover, the probe was submerged into each of the water sample then, the reading was recorded after the stability indicator disappeared. At the end of each sample measurement, deionized water was used to rinse the probe so as to avoid cross contamination among different samples. Turbidity meter HANNA HI 93703) was used to measure the water samples and each of the water samples were poured into the sample holder and kept inside for a few minutes. Then, after determining the reading stability, the value for each water sample was recorded.

2.3.2 Laboratory Analysis

The measurements of Total dissolve solid (TDS) in sample bottles were carried out in line with the standard methods used by (APHA, 1995) and filtration process by (Sawyer et al., 1994). Standard methods of water sampling was used for other trace metals such as calcium, Nitrate, magnesium, sulphate, phosphate, iron content, chloride, etc. to determine the amount of chemical contents present in them. Gravimertry method was used in which oven was used to heat the filtrate at more than 100c it was totally evaporated. The result showed that the left over residue represents the quantity of TDS in each of the sample. Determinations of Anions (Nitrate, chloride, sulphate, phosphate,) were done by spectrophotometer (JENWAY Aquanova spectrophotometer) while determination of Cations (potassium, magnesium and calcium) were done by flame photometry method. The standard solution for each tested element was prepared according to its concentration and used to calibrate the system before analyzing each water sample. AAS system was connected to a computer and was used to record the result automatically.

2.4 Statistical and Descriptive Analysis

Statistical and descriptive analysis was done using EVIEWS version 9 software to analyse the correlation between the chemical contents for the hand dug wells and boreholes. All elements were tested so as to know if there is any association among various elements determined and also analysis based on their measure of central tendency and dispersion was done in the study. The Pearson ‘r’ statistics for the t-test was done to show the

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coefficient of their correlation and their significance level (Table 5). Table 6 shows mean median, minimum and maximum values for the chemical elements.

III. RESULTS AND DISCUSSION

Figure 2 shows the location of wells and bore holes as determined from the study. Table 3 below shows the results of the physicochemical analyses for the study. Table 4 shows the summary of the result in table 3 and their comparism with the Standard Organisation of Nigeria SON (2003) standards. Table 5 shows correlation coefficient matrix of all the chemical elements analyzed. Table 2 shows the safe limits by SON for determining water quality.

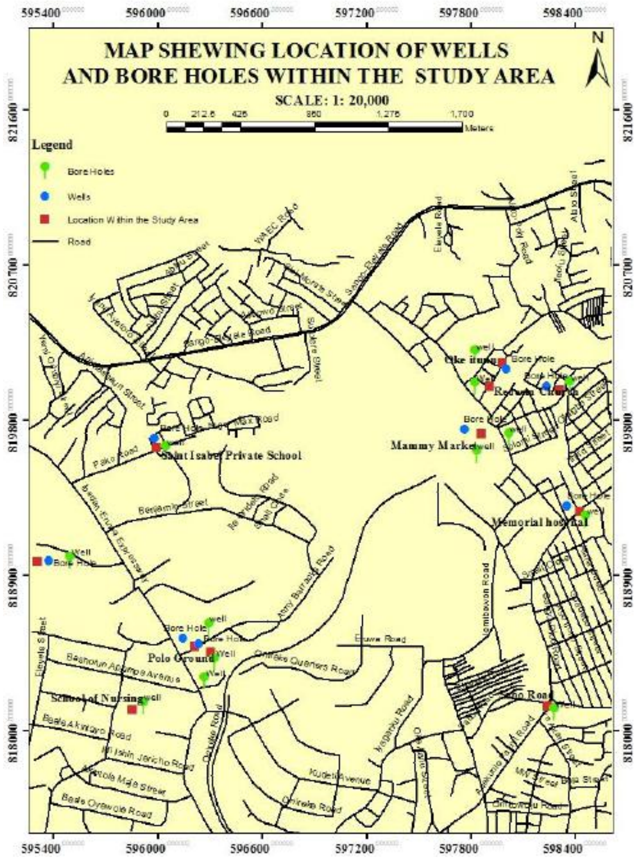

Fig. 2: Composite Map of the Study

Table 2: showing the safe limits by SON for determining water quality

Parameters/Chemical Contents	SON Standards (mg/l)
Ph	6.5 – 8.5
Turbidity	5
Conductivity (us/cm)	1000
Total Dissolved Solid	500
Total Hardness	150
Chloride	250
Nitrate	50
Sulphate	200
Calcium	100
Iron	0.3
Carbonate	500
Magnesium	150

Source: Standard Organisation of Nigeria (2003)

Table 3. Concentration of Physicochemical Parameters in Groundwater Samples of the Study Area

Sample No	pH	Turbidity (ntu)	EC (ucm)	Hardness (mg/L)	TDS (mg/L)	HCO3- (mg/L)	Cl- (mg/L)	NO_3- (mg/L)	SO42- (mg/L)	PO4 3- (mg/L)	Mg (mg/L)	Fe (mg/L)	Ca (mg/L)	Na (mg/L)
Police Headquarters, Eleyele along Ibadan-Eruwa Expressway, Ibadan														
W	7.4	4.06	412	98.2	140.1	125.0	50.0	20.2	0.3	0.02	9.72	0.5	26.3	11.4
BH	5.5	3.76	505	54.1	231.7	130.1	75.1	41.8	0.24	0.02	8.01	0.02	14.4	8.2
Army Staff Quarters, Mokola Barrack, Ibadan														

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W	6.3	2.05	536	78.6	170.4	108.8	35.0	14.2	0.33	0.08	22.8	0.01	32.2	12.5
W	7.2	7.66	453	56.0	260.8	205.0	70.2	32.1	0.15	0.02	9.15	0.01	36.7	11.5
BH	7.3	1.67	628	50.9	290.4	160.3	65.4	28.8	0.17	0.01	20.5	0.02	33.6	11.0
Mammy Market Mokola Ibadan														
W	6.1	1.95	464	101.7	300.7	163.7	75.6	28.0	0.24	0.02	12.8	0.02	36.8	9.9
W	5.9	2.07	577	79.4	265.8	156.0	62.8	22.2	0.3	0.01	26.3	0.02	20.4	7.5
BH	5.7	1.25	258	56.7	301.9	144.8	45.5	28.8	0.22	0.01	16.2	0.02	26.2	10.7
Oke Itunu Mokola, Ibadan														
W	6.4	2.9	227	100.7	290.5	202.3	165.0	28.4	0.17	0.08	19.4	0.01	39.9	7.2
BH	6.9	3.25	361	88.1	300.2	215.0	75.8	16.2	0.02	0.08	28.4	0.01	57.9	9.4
Ade Royal Mokola Ibadan														
W	5.6	4.48	282	67.4	109.9	122.1	70.0	18.6	0.02	0.2	35.4	0.03	46.3	10.5
BH	7.1	5.86	144	56.6	170.0	217.4	40.0	21.8	0.2	0.12	10.3	0.07	33.5	9.9
Redeemed Christian Church of God Mokola, Sango Road, Ibadan														
W	6.0	4.02	124	86.2	236.3	146.0	52.4	13.6	0.15	0.03	14.8	0.02	20.7	6.8
Sabo Road Mokola, Ibadan														
W	4.7	2.37	303	55.8	240.6	151.2	75.0	18.4	0.13	0.12	43.7	0.01	26.6	7.2
Saint Isabel Private School Eleyele-Mokola Ibadan														
W	5.4	8.33	278	58.7	220.2	168.0	90.2	42.1	0.24	0.1	4.58	0.01	31.1	6.2
BH	5.9	5.03	377	61.1	230.3	152.4	95.0	45.0	0.09	0.14	6.87	0.03	26.1	6.1
Memorial Hospital Mokola, Ibadan														
W	5.7	3.23	319	76.4	176.2	152.0	70.0	21.4	0.05	0.2	11.4	0.02	21.7	8.2
BH	6.9	4.01	402	59.2	163.7	118.2	35.6	13.2	0.2	0.08	2.3	0.02	29.4	9.4
School of Nursing Eleyele														
W	5.6	6.68	274	54.4	142.6	148.0	52.2	18.6	0.3	0.1	3.43	0.03	23.4	6.0
Polo Ground Mokola, Ibadan														
W	5.9	2.82	305	87.5	278.8	180.2	70.2	42.0	0.14	0.1	5.7	0.02	22.8	8.9
BH	6.1	3.96	351	57.0	167.1	172.6	50.0	42.8	0.2	0.1	7.2	0.02	31.3	9.5
SON Std Safe Limit	6.5-8.5	5	1000	150	500	500	250	50	100	0.5	0.2	0.3	100	200

W = Hand-dug Wells, BH = Bore Holes

Table 4: Summary of the physicochemical Analyses Results in comparism with SON (2003) Standards for Drinking Water.

Parameter mg/l	**Range**		**Mean**	**Maximum Permissible SON Standard**	**No of samples above permissible level**
	Lowest	Highest			
Ph	4.7	7.4	6.2	6.5 – 8.5	Nil
Turbidity	1.25	8.33	3.88	5	3
Conductivity	124	628	361	1000	Nil
Total Hardness	50.9	101	70.7	150	
Total Dissolve Solid (TDS)	109	301.9	223.2	500	Nil
Bicarbonate	108.8	217.4	159	500	Nil
Chloride	35	95	67.7	250	Nil
Nitrate	13.2	45	26.6	50	Nil
Sulphate	0.02	0.3	0.18	200	Nil
Phosphate	0.01	0.2	0.07	0.5	Nil
Magnesium	2.3	43.7	15.2	150	Nil
Iron	0.01	0.5	0.05	0.3	1
Calcium	14.4	57.9	30.3	100	Nil
Sodium	6.0	12.5	8.9	200	Nil

Source: Author compiled

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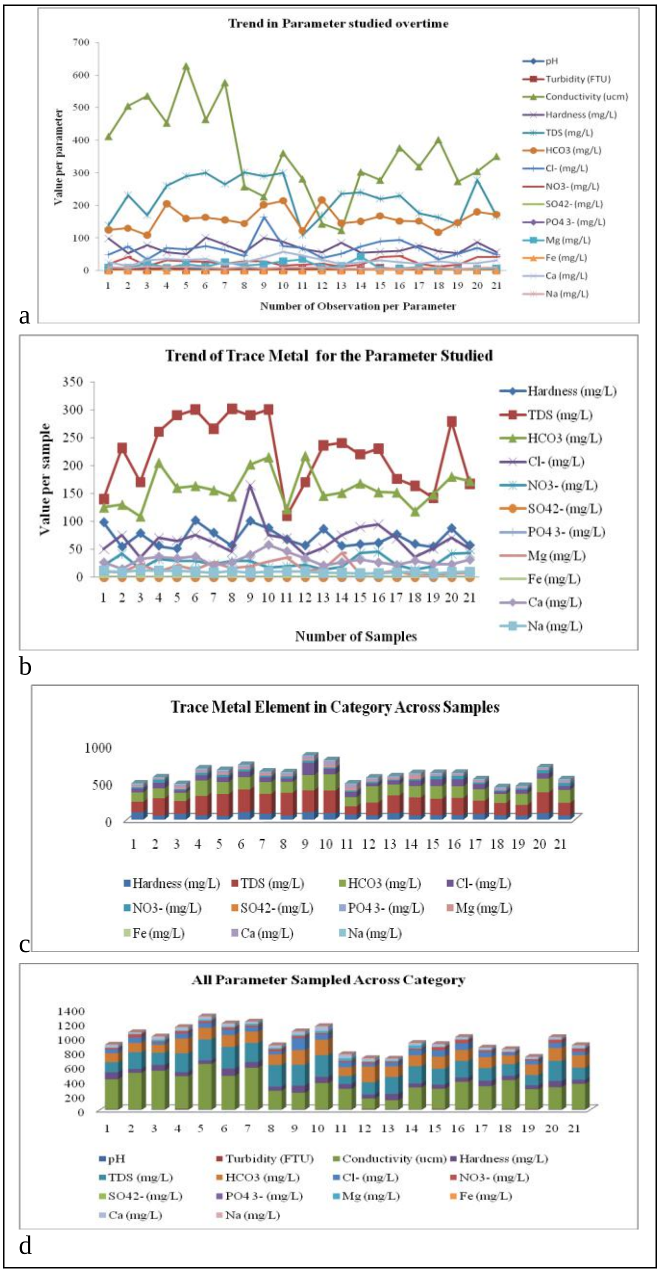

Fig. 3(a-d): Chart showing the chemical contents for both Hand dug wells and Boreholes

3.1 Result of chemical content analysis for both Hand dug wells and Boreholes

Measurements of pH are measured in relation to the acidity or alkalinity of the water. It is acidic if the pH value is below 7.0 while, alkaline if the pH value is higher than 7.0. Corrosion of metal pipes and plumbing system is to acidity while the disinfectant is to alkalinity in water. SON, (2003) has recommended maximum permissible limit of pH from 6.5 to 8.5 (Table 2). At all locations for hand dug wells, pH values ranged from (4.7 to 7.4) and that of boreholes ranged from (5.5 to 6.9). Therefore, the values for both the hand dug wells and borehole ranged from (4.7 to 7.4) and the values were within the limits set by (SON, 2003) (Table 4). The values of electrical conductivity (EC) of hand dug wells ranged from 124 to 577 microhoms/cm and borehole ranged from 144 to 628 microhoms/cm, then, the values for both wells and boreholes ranged from 124 microhoms/cm to 628 microhoms/cm which are within the permissible range of 1000 microhoms/cm by SON. The results of the turbidity results for hand dug wells ranged from 1.95 to 8.33 ntu and boreholes ranged from 1.25 to 5.86 ntu, then the values for both wells and boreholes ranged from ranges from 1.25 ntu to 8.33 ntu which are within the limit 5 nephelometric turbidity unit (ntu) prescribed by SON for drinking water.

The total dissolve solid (TDS) for hand dug wells ranged from 109.9 to 300.7 mg/L and boreholes ranged from 163.7 to 301.9 mg/L, then the values for both hand dug wells and boreholes ranged from 109mg/L to 301.9 mg/L which are lower than the allowable limits of 500 mg/L by (SON, 2003) standard of 500 mg/L. Water with more than 500 mg/L of TDS is not good for drinking water. Several factors may accounts for the presence of total dissolve solid obtained from the water samples collected. Most of the locations are within residential areas where septic tanks are indiscriminately site around the wells.

The result of the total hardness in this study for the hand dug wells ranged 54.4 to 101.7 mg/L and boreholes ranged from 50.9 to 88.1 mg/L, then, both the hand dug wells and boreholes ranged from 50.9 mg/L and 101 mg/L and are within the limit set by (SON, 2003). According to the classification of groundwater based on hardness by (Sawyer and McCarthy, 1987), total samples of 88.3% assessed were soft and 3.3% are hard, thereby making the groundwater suitable for drinking. Water with total hardness value greater than 150mg/L is designated as being hard; soft water have values less than 60ml/L (Freeze, and Cherry, 1979). Sulphate content in water in the study area for the hand dug wells ranged from 0.02 to 0.33 mg/L and boreholes ranged from 0.02 to 0.24 mg/L, then both the hand dug wells and boreholes range between 0.02 mg/L to 0.33 mg/L and considered generally low compared with the safe limits of 200mg/L minimum prescribed by (SON, 2003). With recommended limit of 250 mg/L for $CaSO_4$, $NaSO_4$, and $ZnSO_4$, sulphate could lead to problem of sense of taste if associated with some cations. More of $SO4^{2-}$ in groundwater could be associated to the geology of soil, interaction between clay and sandy soil could encourage sulphide such as pyrite from stratified matter reacting with water to produce $SO4^{2-}$ (Olobaniyi and Owoyemi, 2006). There is no health impacts recorded for high sulphate intake (SON, 2007). Excess concentrations of

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sulphate in groundwater not an indication to health hazard but can cause scale formation and may lead to a bitter taste in water which can result in laxative effect of humans and young livestock (Orewole et al., 2007).

According to the Department of National Health and Welfare, Canada, it was reported that, the chloride comes from natural and man-made sources are the main sources of chloride in groundwater. The sources are agricultural runoff, inorganic fertilizers, industrial and septic tank effluents, animal feed stocks. Chloride is not harmful to human at low concentration but could alter the taste of water at concentrations above 250 mg/L. The values of chloride for hand dug wells ranged from 35 to 165 mg/L and boreholes ranged from 35.6 to 95 mg/L, the both hand dug wells and boreholes ranged 35.0 and 95 mg/L and the result are within the safe limit set by (SON, 2003). The Hardness is directly related to Calcium and Magnesium content in water is related to hardness. Moreover, in this study, the Calcium contents from hand dug wells ranged from 20.4 to 46.3 mg/L and boreholes ranged from 14.4 to 57.9 mg/L, then both the hand dug wells and boreholes ranged between 14.4 mg/L to 57.9mg/L which are below the permissible of 100 mg/L limit set by (SON, 2003). The magnesium content for hand dug wells ranged from 3.43 to 43.7 mg/L and boreholes ranged from 2.3 to 28.4 mg/L, then both the hand dug wells and boreholes ranged from 2.3 mg/L to 43.7 mg/L which are below the permissible limit of 150 mg/L by WHO. Magnesium (Mg^{2+}) does not show any side effect since it is an essential element required by the human body (Frantisek, 2003).

Nitrates for hand dug wells ranged from 13.6 to 42.1 mg/L and boreholes ranged from 13.2 to 45 mg/L, the both the hand dug wells and boreholes ranged between 13.2 mg/l to 45 mg/l and are very low compared to the standard limit of 50 mg/L set by SON. Phosphate for hand dug wells ranged from 0.01 to 0.2 mg/L and boreholes ranged from 0.01 to 0.14 mg/L then both the hand dug wells and boreholes ranged between 0.01 mg/L to 0.2 mg/L and was very low compared to the permissible limit of 0.5 mg/L by (SON, 2003) (Table 2).

High nitrate values observed in some locations were due to poultry rearing and cassava processing wastes dump in the area. The concentration of bicarbonate HCO_3 for hand dug wells ranged from 108 to 205 mg/L and boreholes ranged from 118.2 to 217.4 mg/L, the both the hand dug wells and boreholes ranged from 108 mg/l to 217 mg/L and are within 100-500mg/L permissible limit set by (SON, 2003) for bicarbonate contents in water. HCO3- has no effect as both the wet and the dry season showed no correlation effects and no health-based guidelines were indicated for HCO3- by (SON, 2003). Sodium is an important component of most groundwater.

The concentration of sodium from hand dug wells present ranged from 6 to 12.5 and boreholes ranged from 6.1 to 11 mg/L, then both the hand dug wells and boreholes ranged between 6.0 mg/L and 12.5 mg/L are considerably not exceeds the permissible limit of 200 mg/L set by (SON, 2003). Iron ranged between (0.01 - 0.5) mg/L. Only in Police headquarters is found having iron content of 0.5 mg/L higher than the (SON, 2003)maximum permissible of 0.3 mg/L. pH, basin hydrological conditions; local geological structure are some of the crucial factors that could influence the ability of being able to dissolve and resulting in iron content as pointed out by (Amadi et al., 1989). However, geology of the area could be related to the other source of the iron content (Edet, 2003). Iron is one of important element useful in the body system; moreover, iron toxicity could lead to liver malfunctioning and diabetes mellitus (Klaassen et al, 1986).

3.2 Result of Statistical Analysis

Number of observations (N) = 21

Pearson's correlation (r)

Degree of freedom (df) for a two tailed = N – 2

Degree of freedom (df) = 21 – 2= 19

From the Pearson's critical table at two tailed, the degree of freedom df (19) at 99% (0.01) confidence interval = 0.549, at 95% (0.05) confidence interval = 0.433 and at 90% (0.1) confidence interval = 0.369.

This values were compared with the

Table 5: Correlation Coefficient Matrix for hand dug wells

	CA_mg_l	CL_mg_l	EC_ µS/cm	FE_mg_l	Hardness_mg_l	HCO3_mg_l	Mg_mg_l	NA_mg_l	NO3_mg_l	PH	PO43_mg_l	SO42_mg_l	TDS_mg_l	Turb._ntu
CA_mg_l	1													
CL_mg_l	0.431***	1												
EC_ µS/cm	0.032	-0.346	1											
FE_mg_l	-0.125	-0.232	0.133	1										
Hardness_	0.030	0.253	0.076	0.364	1									

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mg_l														
HCO3_ mg_l _	0.116	0.675*	-0.155	-0.344	0.013	1								
MG_mg_l _	0.266	0.053	0.092	-0.179	-0.136	-0.325	1							
NA_mg_l _	0.422***	-0.355	0.583*	0.355	0.222	-0.295	0.081	1						
NO3_mg_l	0.120	0.418***	-0.025	-0.155	-0.006	0.688*	-0.490	-0.130	1					
PH	0.172	-0.041	0.344	0.571*	0.449**	0.143	-0.423	0.630*	0.042	1				
PO43_mg_l	0.177	0.099	-0.390	-0.278	-0.356	-0.236	0.262	-0.135	-0.061	-0.568	1			
SO42_ mg_l	-0.263	-0.273	0.517**	0.311	0.149	-0.204	-0.294	0.065	-0.070	0.295	-0.656	1		
TDS_mg_l	-0.049	0.481**	0.085	-0.394	0.324	0.751*	-0.070	-0.222	0.501**	0.018	-0.500	0.025	1	
Turb._ntu	0.134	-0.006	-0.271	0.002	-0.617	0.265	-0.496	-0.177	0.363	0.109	0.029	-0.006	-0.251	1

The Correlation coefficient matrix from table 5 above shows the relationship that exists between chemical contents for the hand dug wells. The results shows that Cl^- depends on Ca with r = 0.431 at 90% confidence level. HCO_3 depends on Cl^- with r = 0.675 at 99% confidence level. Na depend on Ca and EC with r = (0.422, 0.584) at 90% and 95% confidence level. NO_3 depend on Cl^- and HCO_3 with r = (0.418, 0.688) at 90% and 99% confidence level. pH depends on Fe, hardness and Na with r = (0.571, 0.449, 0.630) at 90% and 95% confidence level. $SO4^2$ depends on EC with r = (0.517) at 95% confidence level. TDS depends Cl^-, HCO3 and NO_3 with r = (0.481, 0.751, 0.501) at 95% and 99% confidence level.

Table 6: Correlation Coefficient Matrix for the Boreholes

	CA_m g_l _	CL_ mg_l	EC_µS/ cm	FE__ mg_l	Hardness_ mg_l	HCO3_ mg_l	MG_m g_l	NA_ mg_l	NO3_ mg_l	PH	PO43 _mg_l	SO42_ mg_l	TDS_ mg_l	TURB._nt u
Ca_ mg_l	1													
Cl_ mg_l	0.040	1												
EC_ µS/ cm	-0.156	0.426***	1											
Fe_ mg_l	-0.139	-0.306	-0.612	1										
Hardness_ mg_l	0.833*	0.301	-0.190	-0.309	1									
HCO3_ mg_l	0.728*	0.021	-0.473	0.436**	0.524**	1								
Mg_ mg_l	0.731*	0.256	0.129	-0.291	0.593*	0.561*	1							
Na__MG_L_	0.269	-0.686	-0.016	-0.009	-0.135	0.192	0.428***	1						
NO3_ mg_l	-0.589	0.523**	0.216	-0.070	-0.421	-0.257	-0.334	-0.524	1					
PH	0.618*	-0.308	0.060	0.262	0.193	0.469**	0.340	0.476**	-0.712	1				
PO43_ mg_l	0.229	0.115	-0.511	0.470**	0.273	0.403***	-0.352	-0.575	0.062	0.136	1			
SO42___MG _L	-0.778	-0.594	-0.021	0.241	-0.841	-0.503	-0.577	0.323	0.196	-0.288	-0.409	1		
TDS_ mg_l	0.307	0.438**	0.317	-0.485	0.329	0.078	0.821*	0.233	-0.057	-0.065	-0.594	-0.395	1	
TURB_ntu	-0.058	0.052	-0.444	0.653*	0.056	0.297	-0.530	-0.589	0.093	0.073	0.855*	-0.095	-0.752	1

The Correlation coefficient matrix from table 6 above shows the relationship that exists between chemical contents for the boreholes. The results shows that EC depends on Cl^- with r = 0.426 at 90% confidence level. Water hardness depends on Ca with r = 0.833 at 99% confidence level. HCO_3 depends on Ca, Fe and water hardness with r = (0.728, 0.436, 0.524) at 95% and 99% confidence level. Mg depends on Ca, water hardness and HCO_3 with r = (0.731, 0.593, 0.561) at 99% confidence level. Na depends on Mg with r = (0.428) at 90% confidence level. NO_3 depends on Cl^- with r = (0.523) at 95% confidence level. pH depends on Ca, HCO3 and Nawith r = (0.618, 0.469, 0.476) at 99% and 95% confidence level. $PO4^3$ depends on Fe and HCO_3 with r = (0.470, 0.403) at 95% and 90% confidence level. TDS depends on Cl^- and Mg with r = (0.438, 0.821) at 95% and 90% confidence level. Lastly, Turbidity depends on Fe and PO_4 with r = (0.653, 0.885) at 99% confidence level.

Table 7: Correlation coefficient matrix for the Chemical Contents for both hand dug wells and Boreholes

	CA (mg/L)	CL (mg/L)	EC.(ɥcm)	FE (mg/L)	Hardness (mg_l)	HCO_3 (mg/L)	MG (mg/L)	NA (mg/L)	NO_3 (mg/L)	PH	$PO4^{-3}$ (mg/L)	SO_4^2(mg/L)	TDS (mg/L)	Turb_ntu
CA (mg/L)	1													
CL (mg/L)	0.239	1												
EC. (ɥcm)	-0.050	-0.127	1											
FE (mg/L)	-0.105	-0.184	0.044	1										
Hardness (mg_l)	0.215	0.327	-0.054	0.332	1									
HCO_3(mg/L)	0.442**	0.398***	-0.282	-0.227	0.092	1								
MG (mg/L)	0.384	0.134	0.078	-0.140	0.112	-0.046	1							
NA (mg/L)	0.350	-0.441	0.392***	0.287	0.063	-0.104	0.128	1						
NO_3 (mg/L)	-0.223	0.357	0.109	-0.142	-0.234	0.244	-0.445	-0.215	1					
PH	0.380***	-0.166	0.251	0.410***	0.179	0.300	-0.246	0.589*	-0.190	1				
PO_4^3 (mg/L)	0.176	0.123	-0.432	-0.193	-0.129	-0.0134	0.130	-0.254	-0.041	-0.362	1			
SO_4^2 (mg/L)	-0.448	-0.302	0.313	0.295	0.006	-0.314	-0.320	0.104	-0.010	0.072	-0.567	1		
TDS (mg/L)	0.119	0.425***	0.184	-0.356	0.226	0.475**	0.151	-0.076	0.280	0.021	-0.533	-0.113	1	
TBD_ntu_	0.045	0.031	-0.327	0.049	-0.356	0.248	-0.468	-0.282	0.219	0.060	0.243	-0.010	-0.398	1

*, ** and *** denotes 1% (0.01), 5% (0.05) and 10% (0.1) significance level respectively for a 2 tailed Test (Significant level at 0.01 *, 0.05** and 0.1***)

The Correlation coefficient matrix from table 7 above shows the relationship that exists between chemical contents both from the hand dug wells and boreholes. The results shows that HCO_3 depends on increase in Ca at 95% confidence level with (r = 0.442) which shows positive and week relationship/correlation and higher than the Pearson's critical value (r) of 0.433 and Cl at 90% confidence level (r = 0.398) which shows positive and week relationship/correlation and higher than the Pearson's critical value (r) of 0. 369. Increase in Na^+ depends on increase in EC at 90% confidence level with (r = 0.392) which shows week relationship/correlation and higher than the Pearson's critical value (r) of 0. 369. The result also shows that increase in pH depends on Ca and Fe at 90% confidence level with (r = 0.380, 0.410) which shows positive and week relationship/correlation between pH (Ca, Fe) and higher than the Pearson's critical value (r) of 0. 369 and Na^+ which also shows strong relationship/correlation between (pH and Na^+). Therefore, high correlations that exist between pH and Na^+ showed that the two chemical contents are from the same source (Edet et al., 2011). The result of TDS results in increase in Cl^- at 90% confidence level with (r = 0.425) which is higher than the Pearson's critical value (r = 0.369) and HCO_3 at 95% confidence level with (r = 0.475) which showed positive relationship between TDS and Cl, $HC0_3$ and higher than the Pearson's critical value (r = 0.433).

Table 8: Descriptive statistics for the parameter study

	CA (mg/l)	CL (mg/l)	COND (ɥcm)	FE (mg/l)	Hardness (mg/L)	HCO_3 (mg/L)	MG (mg/l)	NA (mg/l)	NO_3 (mg/l)	PH	PO_4^3 (mg/l)	SO_4^2 (mg/l)	TDS (mg/l)	TURB_ ftu
Mean	30.348	67.667	360.952	0.044	70.700	159.005	15.19	8.952	26.581	6.171	0.078	0.184	223.3	3.877
Median	29.40	70.000	351	0.020	61.10	152.4	11.4	9.40	22.2	6.00	0.08	0.20	231.7	3.76

	0				0	00	0	0	0	0	0	0		0
Max.	57.900	165.000	628	0.500	101.700	217.400	43.70	12.50	45.00	7.400	0.200	0.330	301.9	8.330
Min.	14.400	35.000	124	0.010	50.900	108.800	2.300	6.000	13.200	4.700	0.010	0.020	109.9	1.250
Std. Dev.	9.760	27.810	133.004	0.105	17.243	31.200	11.01	1.945	10.655	0.721	0.059	0.090	61.18	1.936
Skewness	1.037	1.995	0.226	4.147	0.572	0.422	1.071	0.008	0.503	0.187	0.561	-0.28	-0.23	0.847
Kurtosis	4.329	8.243	2.483	18.477	1.842	2.371	3.424	1.893	1.893	2.310	2.574	2.331	1.737	2.960
Jarque-Bera	5.314	37.984	0.413	269.767	2.318	0.970	4.174	1.073	1.958	0.540	1.262	0.659	1.579	2.515
Prob.	0.070	0.000	0.813	0.000	0.314	0.616	0.124	0.585	0.376	0.764	0.532	0.719	0.454	0.284
Sum	637.300	1421.00	7580	0.920	1484.70	3339.10	319	188.	558.2	129.6	1.640	3.860	4688	81.41
Sum Sq. Dev.	1905.21	15468.	353803	0.222	5946.28	19468.2	2426	75.65	2271	10.40	0.069	0.161	74853	74.96
Obs.	21	21	21	21	21	21	21	21	21	21	21	21	21	21

The major chemical parameters that are mostly with high concentrate in the water sample are; electrical conductivity (EC) with (360.952, 351.000, 628.000, 124.000), Hydrogen carbonate (HCO_3) with (159.005, 152.400, 217.400, 108.800) with high value in average mean, median, maximum and minimum, total dissolve solid (TDS) while other are total hardness with (70.700, 61.100, 101.700, 50.900), Chloride (CL) with (67.667, 70.000, 165.000, 35.000), calcium (Ca) with (30.348, 29.4, 57.900, 14.40), NO_3 with (26.581, 22.200, 45.000, 13.200) and those with low content are magnesium (Mg) with (15.189, 11.400, 43.7, 2.300), sodium (Na) with (8.952, 9.400, 12.500, 6.000), pH with (6.171, 6.000, 7.400, 4.700) which all falls with the WHO limit 0f 6.5-7.5 and turbidity with (3.877, 3.760, 8.330, 1.250). Those with lowest content intake are iron (Fe) with 0.044, PO_4^3 with 0.078, SO_4^2 with 0.184. Though. The descriptive analysis shows that all the parameters are within the WHO limits.

IV. CONCLUSION

The physicochemical assessment of groundwater in Mokola-Eleyele, Ibadan, Nigeria was assessed. From the findings of the study, it showed that the chemical contents investigated were found below the SON limits. Therefore, the groundwater samples from the hand dug wells and borehole could generally be classified as of good quality, portable for drinking and fit for other domestic purposes. Generally, correlation analysis carried out helps in understanding the nature of extent of relationship between the chemical contents present in both the hand dug wells and boreholes in the study area. The result from the study will help in knowing the type of treatment to be carried out on the hand dug well and the boreholes that are presently in use and the one to use in the future so as to prevent people from contacting diseases

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