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WATER QUALITY ASSESSMENT OF HAND-DUG WELLS IN APAPA LOCAL GOVERNMENT AREA OF LAGOS STATE

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Abstract
This study examines water quality assessment of hand-dug wells in Apapa LGA of Lagos State. The aim of the study was to ascertain suitability of quality hand-dug wells. Thirty water samples were collected from hand-dug wells from varied locations from the three major land use types and measured for six physical parameters (FTU, DO, TSS, pH, EC, and TDS) and eight (8) chemical parameters (Cl^-, SO_4^{2-}, NO^{3-}, PO_4^{3-}, Ca, Mg, Na, and K). The result shows that the quality of sample groundwater was unfit and unsatisfactory for consumption. Some of the analysed parameters failed to conform to water quality index and water quality recommended standards. The pH of groundwater samples indicates slightly alkaline close to neutral condition (7.4). The FTU, TDS and EC (13.0, 1100.0, and 1642.0) of the detected level were slightly far above the WHO recommended limit. The O and TSS level detected were far less then WHO accepted recommended limit. Analyses of the chemical parameters shows that only the detected level of Na (210.16) was far above the recommended limit (200) while others (Cl^-, SO_4^{2-}, NO^{3-}, PO_4^{3-}, Ca, Mg, and K) are all within the minimum and maximum range limit. The way forward is for strict compliance to environmental laws, policy and recommend routine monitoring and further treatment of hand-dug wells for consumption.

Keywords: Physico-chemical, Heavy metal parameters, Groundwater samples, Water quality, Land-use.

Introduction

Water quality is the description of the state of chemical, physical, and biological characteristics of water and to ascertain it suitability of uses. There is linkage between the surface and groundwater quality. Whatever contaminants present on the surfaces could infiltrated into the ground. The chemical components of groundwater include gases, metals iron lead, nitrate, nutrient, nitrogen, phosphorus, pesticides, and organic compound that dissolved in water even when the water looks clean. The physical components are water colour, temperature, taste, odour, and turbidity while the biological components are the level of bacteria viruses, and algae, insect (Chapman, 1996; Aderibigbe, Awoyemi, Osagbemi, 2008; Ayeni, Balogun, Soneye, 2011; Akoteyon and Soladoye, 2011; Cunningham and Cunningham, 2011; 2015).

Naturally, water is never pure in chemical sense. It contains impurities of various kinds dissolved as well as suspended particles. These include dissolved gases, dissolved minerals, suspended matter and microbes which are natural impurities derived from the atmosphere, catchment areas and soil. They are very low in amounts and naturally do not pollute water. However, the quality of natural water is influenced by several other factors that have the capacity to make water undesirable. Any physical, biological, or chemical change in water quality that adversely affects living organisms or makes water unsuitable for desired uses might be considered pollution (Wright and Nebel, 2002; Adelegan, 2004; Strahler and Strahler, 2006; Iqbal, 2011). In essence, water pollutant is anything that degrades water quality. It includes all of the waste materials that can't be naturally counteracted by water. Anything that is added to the natural taste, look and colour of water, little above and beyond its capability to interrupt and degrade it is pollution (Christopherson, 2007; Gohil, 2007; Agbebaku, 2015; Soladoyin and Agbebaku, 2015).

Water, just like air and land resources are key essentials of life. Water gives life but when not well treated, it leads to loss of lives, death of plants and animals. Water is one of the most important resources of the earth. It constitutes about 70% of human body composition and about 60% for plant growth. One of the greatest threats to health remains lack of clean water and sanitation (Strahler and Strahler, 2006; Agbebaku, 2015). The nature of the soil types, structures and matrixes to a great extent determines how slow or fast the soil can be polluted and these pollutions varies from one aquafer to another. These pollutants infiltrate and seeps laterally and vertically from one soil aquifer to another ad this determine ground water quality (Strahler and Strahler, 2006). Groundwater quality of the earth surface is a function of how finest, cleanest and states of the various segments of the soil aquifers one hand the activities of man that generates pollutants such as industrial, domestics, to measure a few capable of negative impacts on the water source. Access to sources of water in Nigeria shows that 48% (about 67 million Nigerians) depends on surface water for domestic use, 57% (79 million) use hand dug wells, 20% (27.8 million) harvest rain water, 14% (19.5 million) have access to pipe borne water, and 14% have access to borehole water sources (FGN, 2007). Globally, about 80% of all diseases and death in developing country are water-related as a result of polluted water (Strahler and Strahler, 2006; Ayeni *et al.*, 2011; Aderibigbe et al; 2008).

However, the quality of natural water is controlled by several factors like geological bedrocks of the area, the seasons of the year and natural streams discharge. Groundwater pollution is caused by the presence of undesirable and hazardous materials and pathogens beyond certain limits. Much of the pollution is due to anthropogenic activities like discharge of sewage, effluents and waste from domestic and industrial establishment, particulate matter and metals and their compounds due to mining and metallurgy, fertilizer and pesticide, runoffs from agricultural activities (Chapman, 1996; Wright and Nebel, 2002; Strahler and Strahler, 2006; Gohil, 2007; Wright and Boorse, 2011; Agbebaku, 2015).

The study area is where major socio-economic activities (port activities and industries) in the state are highly concentrated and explored. Residences pay dearly for water supply. Inhabitants spend about 5% to 20% (depending on the number per household, consumption rate and standard of living) of their incomes on purchase of water into large storage tanks capacity which ranges from 300 to 10, 000 liters (Agbebaku, 2015). This is due to poor supply and difficulties in acquisition of water from bore holes and hand-dug wells.

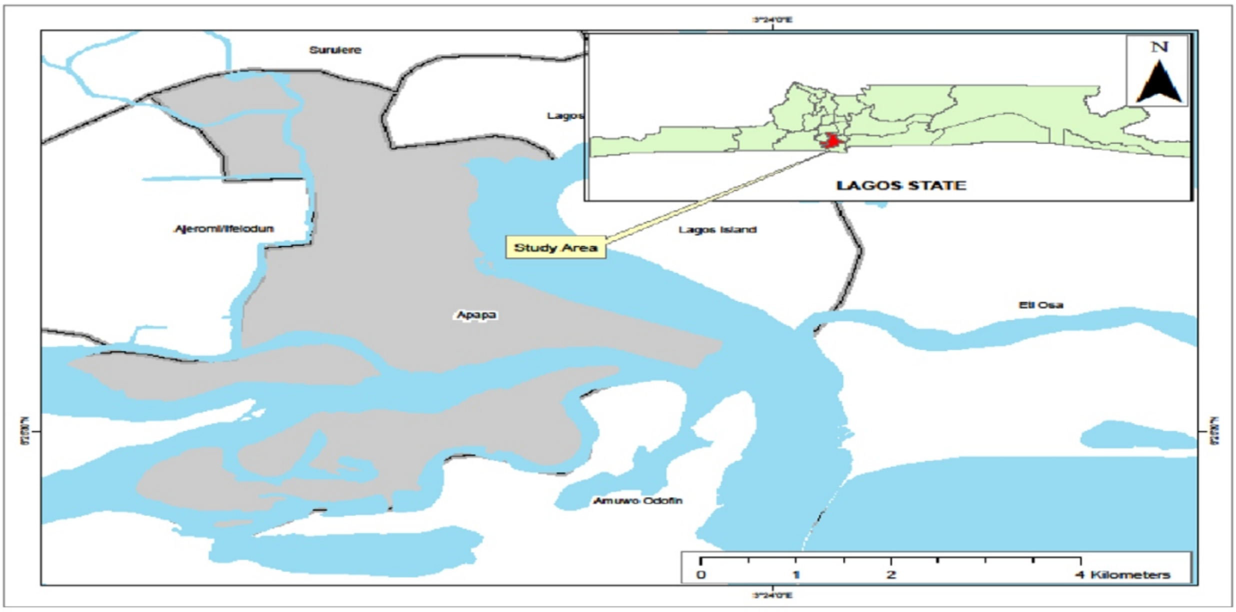

Figure 1: Map of Lagos State and the Study Area.
Source: GIS and Cartography Unit, LASU (2019)

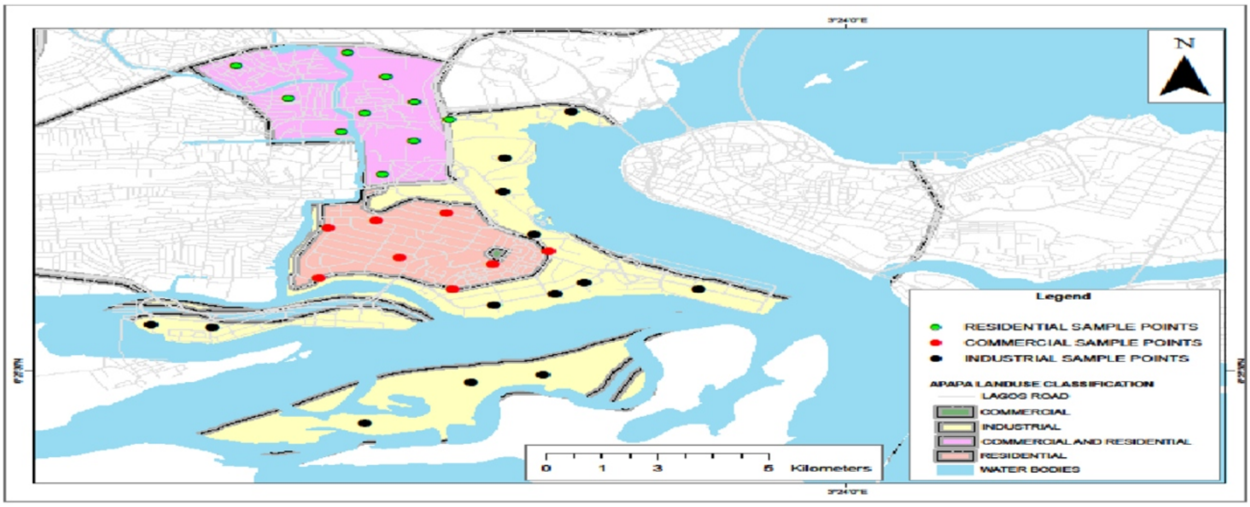

Figure 2: Geographical Spread of 30 Sample Locations of Three Major Land use Types of the Study Area.
Source: GIS and Cartography Unit, LASU (2019)

To this end, the aim of the research is to examine water quality assessment of hand-dug wells and its suitability for drinking purpose while the specific objective is to analyse the physico-chemical and heavy metal parameters in groundwater samples under varied land-uses in Apapa, LGA of Lagos State. Figure 1 and 2 shows map of Lagos State and Apapa Local Government Area while Figure 2 shows the geographical spread of the 30 sample locations of the three major land use types of the study area.

Materials and Methods

The study area is Apapa Local Government Area of Lagos State. This area lies approximately between Latitude $60'22^0$N and $60'24^0$N and Longitude $30'20^0$E and $30'40^0$E. Apapa Local Government Area shares boundaries to the north and west with Lagos Mainland and Ajeromi-Ifelodun Local Government Areas of Lagos State respectively. To the east and south are water bodies that are parts of the Lagos lagoon and the Atlantic Ocean. It has a total land area of 38.5km^2 of which 13km^2 is water (Lagos Bureau of Statistics, 2011). The study area is a hub of socio-economic activity. It is a vast expanse of manufacturing industries. Various industries, ranging from soap making to plastic, paint and cement production, are within the study area. The reserve tanks of major oil companies are in the area. The two major shipping ports in Nigeria namely the Apapa and Tin Can ports are also located there. There are clusters of petrol stations, shopping malls and several other businesses in the area. Several government establishments, including three military barracks are in Apapa. To get primary data, water samples used in the study were collected and analyzed.

Water samples were collected and analysed in the laboratory following American Public Health Association (APHA, 2005) procedure for water quality. The thirty hand-dug wells selected for study were from three major land-use types namely commercial, industrial and residential land uses. On the whole, ten of the wells were within the commercial category while twelve and eight were from the industrial and residential respectively. Each well was allocated a number for reference and identification purposes. The land use types are indicators of the level of anthropogenic activities in each area. Classifying the study area into strict land use zones was difficult because of the characteristic land use mix feature of the area. The areas designated in this study as commercial are used mainly for commercial purposes such as fuel depots and shopping areas. The industrial areas are distinct and comprise the places where factories are. However, the residential areas are mixed as they include locations that are used largely for administrative but as well as commercial purposes.

The physical parameters considered include pH, turbidity, dissolved oxygen (DO), total dissolved solid (TDS), total suspended solid (TSS) and electrical conductivity (EC). The chemical parameters tested include major cations such as magnesium (Mg), calcium (Ca), sodium (Na) and potassium (K). Also included are major anions namely nitrate (NO3), chloride (Cl), sulphate (SO43-), and phosphate (PO43-). Statistical methods of correlation and one-way analysis of variance (ANOVA) were adopted for use in the study. Correlation analysis was used to identify relationships between water parameters. ANOVA was used to determine significant differences in groundwater parameters across land uses at 0.05% level of significance. The Scheffe post hoc test was conducted to identify the land use groups per parameter that differ. The land use groups were identified as Group 1 (Commercial), Group 2 (Industrial) and Group 3 (Residential).

Results and Discussion

Results of tests carried out on water samples were summarized and presented in varied Tables. Collected data from the 3 different selected land use types were presented in Tables 1 to 3 in line with WHO minimum and maximum standard limit for the examined water quality variables.

Tables 1 to 3 shows the laboratory results for groundwater quality in industrial, commercial and residential land uses. Tables 1 to 3 of serial number 1 to 30 revealed that 30 water samples were collected and analysed; the 1st ten samples were analysed from commercial land use locations. The 2nd eight samples were analysed from institutional locations while the remaining twelve were analysed from institutional locations. From the results, residential land use type in Tamade Barrack, GRA were (1030 and 1277). These results were only above the limit in one location from the commercial land use, Queen Barrack, Boundary (1294). It was observed that increase in EC directly linked with the TDS. Some areas have their TDS higher above the standard limit of 500.

Table 1: Groundwater Quality in Commercial Land Use Area of Apapa

Variable	T	DO	TSS	pH	EC	TDS	Cl	SO_4^{2-}	NO_3-	PO_4^{3-}	Ca	M_g	Na	K
WHO	**2.5**	**3.0**	**3.0**	**8.5**	**1000**	**500**	**250**	**4.0**	**10**	**0.03**				
C-1	0	6.4	ND	7.1	392	260	10	12	3.15	0.02	14	8	6.11	1.72
2	0	6.3	ND	7.2	392	263	8	12	3.2	0.02	14	6	4.56	1.39
3	0	5.2	ND	7.2	275	184	10	8	2.19	0.01	10	6	5.89	1.4
4	4	5.7	5	7.3	1030	683	212	23	6.3	0.03	34	12	102.12	18.32
5	7	5.8	9	7.3	1277	859	350	33	10.8	0.05	42	14	120.3	18.32
6	2	6.2	2	7.3	288	194	14	10	2.35	0.01	10	4	7.08	2.54
7	2	6.1	3	7.2	496	332	14	14	3.72	0.02	12	4	6.96	2.38
8	0	6.3	2	7.2	534	357	16	14	3.8	0.02	12	6	7.38	2.71
9	10	6	12	7.2	1294	871	38	42	9.25	0.05	44	10	192.06	38.5
10	0	6.4	ND	7.1	572	382	20	18	4.63	0.04	14	6	7.7	2.59

Source: Fieldwork, 2019

Table 2: Groundwater Quality in Residential Land Use Area of Apapa

Variable	T	DO	TSS	pH	EC	TDS	Cl	SO_4^{2-}	NO_3-	PO_4^{3-}	Ca	M_g	Na	K
WHO	**2.5**	**3.0**	**3.0**	**8.5**	**1000**	**500**	**250**	**4.0**	**10**	**0.03**				
R-21	0	6.4	ND	7.1	392	260	10	12	3.15	0.02	14	8	6.11	1.72
22	0	6.3	ND	7.2	392	263	8	12	3.2	0.02	14	6	4.56	1.39
23	0	5.2	ND	7.2	275	184	10	8	2.19	0.01	10	6	5.89	1.4
24	4	5.7	5	7.3	1030	683	212	23	6.3	0.03	34	12	102.12	18.32
25	7	5.8	9	7.3	1277	859	350	33	10.8	0.05	42	14	120.3	18.32
26	2	6.2	2	7.3	288	194	14	10	2.35	0.01	10	4	7.08	2.54
27	2	6.1	3	7.2	496	332	14	14	3.72	0.02	12	4	6.96	2.38
28	0	6.3	2	7.2	534	357	16	14	3.8	0.02	12	6	7.38	2.71

Source: Fieldwork, 2019.

Table 3: Groundwater Quality in Industrial Land Use Area of Apapa

Variable	T	D O	TSS	pH	EC	TDS	Cl	SO_4^{2-}	NO_3-	PO_4^{3-}	Ca	M_g	Na	K
WHO	**2.5**	**3.0**	**3.0**	**8.5**	**1000**	**500**	**250**	**4.0**	**10**	**0.03**				
I-11	2	6.3	2	7.1	542	363	34	16	4.48	0.03	16	4	6.98	1.55
12	0	6.4	ND	7.1	545	364	38	16	4.49	0.04	14	6	7.92	2.6
13	2	6.2	3	7.2	842	564	76	26	7.22	0.04	30	8	15.77	6.18
14	3	6	2	7.2	848	568	110	27	7.47	0.05	34	8	45.63	10.32
15	2	6.2	2	7.3	850	590	108	27	6.98	0.05	34	6	40.94	9.86
16	0	6.4	ND	7.3	884	593	30	31	7.54	0.04	38	8	14.58	3.49
17	2	6.2	2	7.3	879	588	40	30	7.5	0.04	34	8	16.89	3.97
18	2	5.9	2	7.2	872	583	56	30	7.5	0.04	32	6	25.28	5.47
19	3	5.8	2	7.1	881	588	44	31	7.49	0.04	36	6	27.92	6.02
20	0	6.1	ND	7.2	880	588	82	29	7.52	0.05	38	6	36.17	8.51
29	2	5.8	2	7.3	1642	1100	460	48	12.39	0.06	52	16	210.16	31.92
30	13	5.4	25	7.4	1191	797	200	37	9.18	0.05	46	10	81.52	19.6

Source: Fieldwork, 2019.

From the industrial land use, both Dockyard and Creek Road have TDS values of 1100 and 797. In the residential land use type, Tamade, Barrack, GRA has (68-859) and Queen Barrack, Boundary has (871) for the commercial area. Furthermore, electrical conductivity was above the maximum standard limit of 1000 in Queen barrack, that of Boundary was 1642 and that of Creek road was 1191. However, Laboratory data were subjected to descriptive analysis which were mean, minimum, maximum, standard deviation and coefficient of variation. The minimum value ranged from zero (turbidity) to 275 (EC), mean also ranged from 0.03 (PO_4^{3-}) to 743.31 (EC), minimum was between 0.06 (PO_4^{3-}) to 1642 (EC). Dissolved oxygen (5.66) accounts for the lowest computed value and magnesium (230.28) accounts for the coefficient of variation.

Table 4 shows the mean concentration of the groundwater parameters in Apapa Local Government area. The implication of high concentration parameter on water quality indicate that the water is not pure (in line with WHO standard) to fulfills the requirement for various uses that is not be suitable for drinking purpose but can serve other uses as washing, toileting and gardening while low concentration of these parameters will be subjected to water treatment for drinking purpose but can also serve other uses.

Table 4: Summary of the Analysis of Groundwater Samples for Parameters under Study

S/N	Parameters	No of Samples	Minimum	Maximum	Mean	Standard Deviation	Variance
1	T	30	0	13.0	2.633	3.2851	10.792
2	DO	30	4.8	6.4	5.917	.4609	.212
3	TSS	30	0	25.0	3.667	5.4856	30.092
4	pH	30	6.5	7.4	7.147	.1961	.038
5	EC	30	203.00	1642.00	702.7333	375.63821	141104.064
6	TDS	30	136	1100	458.37	256.244	65661.137
7	CI	30	8	460	73.07	106.900	11427.513
8	SO_4^{3-}	30	6	48	21.40	11.828	139903
9	NO_3	30	1.64	12.39	5.5883	2.99347	8961.000
10	PO_4	30	.01	.06	.0317	.01599	181.333
11	Ca	30	10	52	25.33	13.466	9.030
12	Mg	30	4	16	7.07	3.005	2934.397
13	Na	30	3.86	210.16	36.3030	54.17008	89.543
14	K	30	1.06	38.50	7.4877	9.46264	

Source: Fieldwork, 2019.

Table 5: Comparison of the Mean Level Detected Parameters with the World Health Standards Water Quality of 2011 and 2015.

S/N	Parameter	Accepted	Levels Detected	WHO Recommended Limits	
	Physical Characteristics			**Minimum Acceptable**	**Maximum Acceptable**
1	Appearance	Clear	Mixed	Clear	Clear
2	Colour	5.0	Mixed	-	Colourless
3	Odour	Unobjectionable	Mixed	Odourless	Odourless
4	pH at 20°C	7.0 - 8.5	7.4	6.50	8.50
5	Turbidity (FTU)	2.5	13.0	-	-
6	Electrical Conductivity **(μScm^{-1})**	900	1642.0	900.0	1200.0
7	Dissolved Oxygen, DO (ppm)	500	6.4	-	500
8	Total Suspended Solids (TSS)	200	25.0	500.0	500
9	Total Dissolved Solid (TDS)	500	1100.0	-	500
10	Temperature	10°C to 15.6°C	Not Detected	-	
11	Taste	Unobjectionable	Mixed	-	Tasteless
	Chemical Characteristics				
1	Chloride Cl (ppm)	200	460.0	200	600
2	Sulphate SO_4^{2-} (ppm)	200	48.0	200	400
3	Nitrate NO_3^-	45	12.39	5	30
4	Phosphate	NS	0.06	-	0.03
5	Nitrite NO_2^-	NS	Not Detected	Nil	Nil
6	Magnesium	30	16.0	Nil	Nil
7	Sodium	-	210.16	30	200
8	Potassium	-	31.72	Nil	Nil
9	Acidity-P (ppm $CaCO_3$)	NS	Not Detected	NS	NS
10	Alkalinity-P (ppm $CaCO_3$)	NS	Not Detected	30	500
11	Total Hardness (ppm $CaCO_3$)	200	Not Detected	30	200
12	Calcium Hardness (ppm $CaCO_3$)	75	Not Detected	75	200
13	Ammonia (ppm)	NS	Not Detected	-	-
14	Iron Fe (ppm)	0.1	Not Detected	0.1	1.0
15	Zinc Zn (ppm)	5.0	Not Detected	5	15
16	Lead Pb (ppm)	0.1	Not Detected	Nil	Nil
17	Arsenic, As (ppm)	0.05	Not Detected	Nil	Nil
18	Mercury, Hg (ppm)	0.001	Not Detected	Nil	Nil
19	Copper Cu (ppm)	0.05	Not Detected	0.005	1.5
20	Sulphite SO_3^{2-}	NS	Not Detected	200	400
21	Cadmium	0.01	Not Detected	0.05	0.05
22	Manganese Mn (ppm)	0.05	Not Detected	0.005	0.5

Source: Field-Laboratory Analysis, (2019) Iqbal, (2011) and Agbebaku, (2015).

Table 6: Posthoc on ANOVA for Land Uses

(I) Code	(J) Code	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Commercial Land use	Residential Land use	-34.13071	83.34680	.912	-237.1892	168.9277
	Industrial Land use	9.10071	83.34680	.993	-193.9577	212.1592
Residential Land use	Commercial Land use	34.13071	83.34680	.912	-168.9277	237.1892
	Industrial Land use	43.23143	83.34680	.863	-159.8270	246.2899
Industrial Land use	Commercial Land use	-9.10071	83.34680	.993	-212.1592	193.9577
	Residential Land use	-43.23143	83.34680	.863	-246.2899	159.8270

Source: Fieldwork, 2019.

However, the soil nature of the matrixes plays an important role in groundwater quality just as in the case of socio-economic activities as in the case of Apapa Local Government Area. Furthermore, Table 5 shown the minimum, maximum, standard deviation and variance statistics for each parameter. Also shown in the Table were the minimum, maximum, standard deviation and variance statistics for each parameter under study.

Table 5 shows the comparison of field-laboratory analysis of the observed water quality in Apapa and its environs with the World Health Standards water quality. The implication of the computed results revealed that where the detected level of examined parameter is higher or lower within the accepted range or standard, then there are bound to be ill-quality of water for human consumption, mainly for the purpose of drinking and cooking but can be used for other purposes as washing, toileting and irrigation. The WHO drinking water standard of 2015 (Geneva) still date is the international reference point for setting water standard (Agbebaku, 2015).

Analysis from Table 6 shows that parameters under industrial land use had the lowest variation, this was followed by commercial land use while differences in parameters under residential was the highest. Table 6 further shows the standard error of 83.34 and significant value of 0.863 that is 86% for the three major land use under the study. The existing difference in groundwater quality in Apapa and its environs was not statistically significant which may be attributed to the location, surface configuration, and proximity of the area to the ocean, hence, being affected by sea water intrusion. Examined parameters were more in groundwater under residential than industrial and commercial according to the mean value. From the industrial land use, it was observed from Table 4, SO_4, PO_4^{3-} and DO were higher the WHO maximum standard limit. This may be attributed to the long period of industrial activities in the area. Furthermore, the influence of high concentration or low concentration of chemicals, lead, heavy metals and nitrate (mostly) are also other determinant factors that makes groundwater quality of hand-dug wells un-pure and unsafe for drinking and cooking purposes and also for effects of these indices on human health.

Conclusions

This study examines water quality assessment of hand-dug wells in Apapa, LGA of Lagos state to ascertain the suitability of hand-dug wells for drinking and cooking purposes. 30 water samples were collected and examined from varied locations from 3 major land use types and a measured for six (6) physical parameters (FTU, DO, TSS, pH, EC, and TDS) and eight (8) chemical parameters (Cl^-, SO_4^{2-}, NO^{3-}, PO_4^{3-}, Ca, Mg, Na, and K) were examined. The result shows that the quality of the sampled groundwater was unfit and unsatisfactory for consumption. Some of the analysed parameters failed to conform to water quality index (WQI) such as: WHO: 2004; CWA: 1969, and NSDWQ; 2007 water quality recommended standards. The pH of groundwater samples indicates slightly alkaline close to neutral condition (7.4). The FTU, TDS and EC (13.0, 1100.0, and 1642.0) of the detected level were slightly far above the WHO recommended limit. Furthermore, the study observed that pathogens and other pollutants enter ground water through improperly designed of wells and inhuman activities of man on the ecosystem.

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