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Evaluation of Seasonal Water Quality of Drinking Water in Six Residential Estates across Ogun State in Nigeria

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ABSTRACT: The use of water to satisfy human without any health risk necessitates the need for assessment of potable water quality for human consumption. Water samples were collected across six selected housing estates for two consecutive dry and wet seasons within Ogun State, and their parameters such as TDS, EC, Mn, Zn, Cd, Pb and Ni were analysed for quality assessment. On spot analysis was carried out for the in-situ parameters using HANNAH water kit. The water samples were digested in triplicates for each estate, and analysed with AAS for the selected heavy metals (HMs). The obtained data were subjected to descriptive and inferential statistics, and the obtained values were compared with WHO, NIS and NESREA standards to ascertain the water quality and potability. Concentrations (mg/ L) of the analysed parameters ranged as TDS: 56.00 ± 10.44 to 162.07 ± 9.81, Cd: 0.01 ± 0.00 to 0.16 ± 0.10, Pb: 0.16 ± 0.02 to 1.69 ± 0.10, Fe: 0.04 ± 0.04 to 4.75 ± 0.21, and Ni: 0.04 ± 0.02 to 0.85 ± 0.04. The EC (µS/ cm) ranged from 42.82 ± 10.59 to 499.12 ± 31.20. The water quality showed seasonal variations, more polluted in the wet season than dry season, which can be attributed to storage tanks, piping systems and runoff from drainages, residential wastes, and the neighbouring small scale industrial activities. The research suggests water treatment for the consumers to get safe water of potable quality.

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Keywords: Community health, Potable water quality, Heavy metals, dry and wet seasons

The importance of water cannot be overemphasized as the existence of life depends on the availability of good water supply. Water is an essential renewable resource that embodies the capacity for sustenance of human, animal and plant life. Water is used for many activities and purposes. It is the most abundant substance on the earth surface occurring not only as surface water in lakes, rivers, rain water and streams but also as groundwater in wells, boreholes and springs (Ayodele and Aturamu, 2011). Water shortages are related to both under-development of potentially available water resources and their uneven distribution, this is coupled with unrelenting population growth and sanitation problems (Tarrass and Benjelloun, 2012). Water is of good quality if it fulfills biological, chemical and physical standards as the maximum allowable level set by the regulatory bodies. Groundwater accounts for about 98 % fresh water and distributes to naturally provide constant water supply. It is usually of high quality when compared with drinking water standards based on two main criteria: either presence of objectionable quality or substances with physiologically adverse effects (Davis and Dewiest, 1966). Deviation from the potable water quality results in water pollution and poses a deadly threat to the consumers. This makes it mandatory for there to be emphasis on the cleanliness of water sources to ensure drinking water quality (Tejuoso, 2006). Water contamination from anthropogenic activities will lead to decline in efficiency of water quality for potable use and cause an adverse impact on ecological functionality. Around 80 % of untreated wastewater is discharged into the environment and globally causes water pollution (WWAP, 2017). So, chemistry of groundwater will change, affect the mineral enrichment and make water unfit for consumption (Ako *et al.,* 1990). Water of poor qualities portends health risks and is dangerous

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because of the potential outbreaks of water-borne diseases. Research indicates that problems of water related diseases, pollution and hazards range globally from 23 to 30 % (WHO, 1997). The indications include infectious diseases related to drinking water, sanitation and food hygiene. Concentrations of the introduced pollutants could restrict function of the endocrine system to cause reproductive, developmental and behavioral problems. Effects on the developing nervous system are not only impaired mental and psychomotor development but also cognitive impairment and behavior abnormalities (WHO and IPCS, 2002). The most common route of exposure to pollutants in water is through drinking contaminated water. Therefore, the present study examined the seasonal water quality of drinking water in six residential estates across Ogun State in Nigeria. The procedure of estimating actual exposure involves analyzing levels of contaminant and comparing with the set standards (WHO, 2003; NIS 554: 2007).

MATERIALS AND METHODS

Study area: Ogun State is located in Southwest of Nigeria with 20 Local Government Areas. The state is situated on Latitude 6.2°N and 7.8°N while on Longitude 3.0°E and 5.0°E sharing boundary with Oyo, Lagos and Ondo States at the North, South and East respectively. The state has a land area of about 16,085km^2 with a population of 3.75 million inhabitants (Omotayo, 2003). The two most important rivers in the state are Ogun and Oyan rivers flowing from Oyo north and Saki respectively into the eastern part of the state forming a confluence at Abeokuta, the state capital. The wet season starts around the middle of March and continues until late October. The dry season commences in November and lasts until February in most locations in the state. Rainfall ranges between 1600 mm and 900 mm annually and the area is warm throughout the year with a temperature between 28 °C to 35 °C. Humidity is between 85 percent and 95 percent.

Water samples collection and analysis: Six prominent housing estates shown in Figure 1 were randomly selected across Ogun state, where both surface and ground water were sampled and assessed for two seasons (dry and wet) in two consecutive years (2018 and 2019). The samples collected where tested to see if they conformed to the set standards of World Health Organization (2003) and Nigeria Industrial Standard (NIS 554: 2007). The critical pollutants assessed across the water samples in the study were TDS, EC, total acidity and alkalinity, phosphate, Na, Fe, Mn, Cu, Ni, Zn, Cd, and Pb.

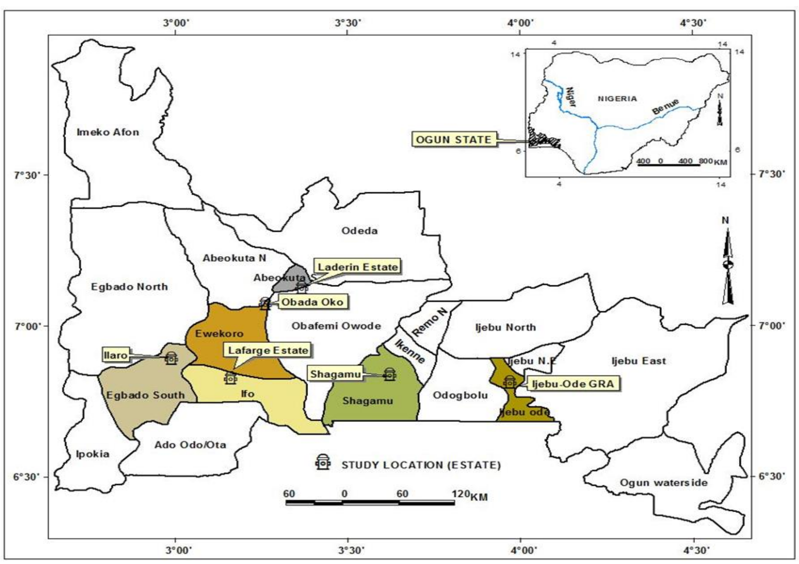

Fig 1: Map of Ogun State Indicating the Study Areas
Source: Cartography laboratory, FUNAAB

On spot Analysis of the in-situ parameters: Using the HANNAH water kit and following the procedure described in the nine-page document of SESDPROC-111-R4 (2018), four in situ parameters: Temperature (°C), pH, dissolved oxygen (DO, mg/ L) and electrical conductivity (mg/ L) were measured instantly on spot in the field. New and pre-cleaned transparent container of 5 L capacity was used to collect water sample at each sampling point. Cleaning was done with detergent and running water, followed subsequently with deionized water and Mill-Q water to ascertain contaminant free container. The Mill-Q water was used to validate accuracy of the water kit before being used at each sampling point across the sites. The probe of the water kit was dipped and the value recorded. Value of each parameter was taken three times to get an average, representative, value using SPSS IBM, Version 22. This was done for the four in situ parameters.

Analysis of the total hardness, acidity and alkalinity: The total hardness of the water samples in laboratory was determined with complexometric analysis using ethylenediaminetetraacetic acid (EDTA). Following the methods described by Sawyer *et al.* (2000), total acidity and total alkalinity were quantified.

Analysis of the nitrate, chloride, sulphate and phosphate: The colorimetric method 1686 described by USEPA (2001) was adopted for nitrate determination. The chloride contents were determined using Mohr Method (4500 B-Cl-; Argentometric Method) (Sawyer *et al..*, 2000). Turbidimetric method description of Elenkova *et al.* (1980) was used to quantify sulphate content. The UV-visible spectrophotometric method used by Oladeji *et al.* (2016) determined the level of phosphate.

Analysis of the water sample Ca, Mg, Na and heavy metal contents: Both Ca and Mg were determined with gravimetric titration method while Na and K were determined with flame photometric method. Each water sample was digested in triplicates with aqua regia (nitric acid, HNO_3 and hydrochloric acid, HCl in the ratio 1 to 3) solution. The filtrates were made to the mark with Milli-Q water. These methods are supported by previous studies (Taiwo *et al.,* 2015; Amujo *et al.*, 2019).

RESULTS AND DISCUSSION

The study assessed quality of the available water across the six selected housing estates where least anthropogenic influences are thought to be minimal for two dry and wet seasons in Nigeria. The potable water standards were considered for comparisons. The determined levels of various parameters classified as in-situ, chemical, anions and cations (macro and micro) elemental parameters are presented in Tables 1-4 for 1st dry, 1st wet, 2nd dry and 2nd wet season respectively. The ranges of values for easy comparison with the two chosen (international: World Health Organization and local: Nigeria Industrial Standards) are presented in Table 5. Assessment of the adequacy of the potable water quality depends on comparing the analysed results with the guideline values, which represents the concentration of a constituent that does not exceed tolerable risk to the health of the consumer over a lifetime of consumption. The guidelines values are established taking into consideration all the available techniques to control, remove or reduce the concentration of the contaminant to the non-harmful concentrations. The aim of national drinking-water limits and standards is to ascertain satisfaction of safe potable water for the consumers without shutting down the insufficiently available or scarce supplied water. Such limits or standards should be applicable to all the supplied water from various sources (stream, hand dug well, borehole or tanker supply).

Table 1: Results of the Water Quality in the 1st Dry Season (2018)

	Shagamu	Shagamu Rv	Ijebu-Ode	Ijebu-Ode Rv	Laderin	Arigbajo Well	Obada-Oko Ts	Ilaro
Temp, ^{O}C	26.77 ± 0.15^{e}	24.23 ± 0.15^{b}	26.27 ± 0.41^{d}	23.63 ± 0.38^{a}	25.47 ± 0.25^{c}	26.30 ± 0.20^{d}	27.60 ± 0.26^{f}	27.63 ± 0.12^{f}
pH	6.98 ± 0.55^{b}	8.23 ± 0.15^{cd}	6.61 ± 0.56^{b}	8.57 ± 0.26^{d}	5.56 ± 0.01^{a}	7.51 ± 1.21^{bc}	6.94 ± 0.46^{b}	5.58 ± 0.30^{a}
EC, µS/ cm	79.52 ± 10.59^{ab}	94.81 ± 74.73^{ab}	42.82 ± 10.59^{a}	293.60 ± 18.35^{c}	238.55 ± 36.70^{c}	116.22 ± 21.19^{b}	61.17 ± 28.03^{ab}	48.93 ± 10.60^{a}
TDS, mg l^{-1}	62.67 ± 10.50^{abc}	95.33 ± 5.77^{d}	61.33 ± 10.02^{ab}	90.00 ± 6.93^{d}	76.33 ± 1.53^{c}	56.00 ± 10.44^{a}	62.33 ± 8.33^{abc}	73.33 ± 1.53^{bc}
Total Hardness, mg l^{-1}	20.00 ± 10.00^{ab}	43.33 ± 4.73^{d}	13.67 ± 3.06^{a}	66.00 ± 4.36^{e}	76.67 ± 1.15^{f}	45.67 ± 6.03^{d}	25.67 ± 1.15^{bc}	32.67 ± 5.51^{c}
Total Acidity, mg l^{-1}	18.38 ± 0.26^{b}	24.40 ± 0.20^{d}	23.67 ± 1.15^{cd}	47.37 ± 1.62^{f}	6.67 ± 1.53^{a}	22.23 ± 0.57^{c}	26.67 ± 1.53^{e}	28.37 ± 0.35^{e}
Total Alkalinity, mg l^{-1}	2.85 ± 0.13^{a}	8.67 ± 1.53^{c}	4.44 ± 0.76^{b}	8.67 ± 0.70^{c}	11.47 ± 0.25^{d}	8.87 ± 0.42^{c}	8.50 ± 0.46^{c}	3.64 ± 0.11^{ab}
Nitrate, NO_3^-, mg l^{-1}	3.31 ± 0.45^{a}	3.30 ± 0.49^{a}	3.61 ± 0.31^{a}	3.64 ± 0.22^{a}	3.74 ± 0.21^{a}	3.44 ± 0.35^{a}	3.74 ± 0.18^{a}	3.76 ± 0.17^{a}
Sulphate, SO_4^{2-}, mg l^{-1}	4.53 ± 0.23^{d}	3.66 ± 0.32^{c}	6.04 ± 0.04^{e}	0.43 ± 0.06^{a}	4.06 ± 0.43^{cd}	3.52 ± 0.33^{c}	1.13 ± 0.05^{b}	4.00 ± 0.62^{cd}
Phosphate, PO_4^{3-}, mg l^{-1}	0.13 ± 0.03^{ab}	0.03 ± 0.03^{a}	0.25 ± 0.04^{b}	0.02 ± 0.01^{a}	0.13 ± 0.02^{ab}	0.04 ± 0.02^{a}	0.24 ± 0.17^{b}	0.21 ± 0.11^{b}
Chloride, Cl^-, mg l^{-1}	20.67 ± 0.83^{a}	44.96 ± 2.74^{d}	22.00 ± 0.40^{ab}	44.47 ± 1.17^{d}	51.87 ± 2.89^{e}	39.33 ± 4.93^{c}	26.03 ± 0.91^{b}	21.73 ± 1.80^{ab}
Ca^{2+}, mg l^{-1}	0.31 ± 0.32^{a}	0.57 ± 0.15^{a}	0.29 ± 0.12^{a}	2.49 ± 0.38^{c}	3.51 ± 0.45^{d}	1.34 ± 0.46^{b}	0.16 ± 0.02^{a}	0.56 ± 0.06^{a}
Mg^{2+}, mg l^{-1}	0.17 ± 0.03^{a}	0.70 ± 0.07^{c}	0.39 ± 0.18^{ab}	2.71 ± 0.26^{d}	4.32 ± 0.27^{e}	0.53 ± 0.06^{bc}	0.47 ± 0.06^{bc}	0.61 ± 0.06^{bc}
Na^+, mg l^{-1}	0.40 ± 0.07^{bc}	0.13 ± 0.04^{ab}	0.36 ± 0.14^{abc}	0.37 ± 0.11^{abc}	0.11 ± 0.07^{a}	0.49 ± 0.24^{c}	0.33 ± 0.21^{abc}	0.30 ± 0.16^{abc}
Cd^{2+}, mg l^{-1}	0.08 ± 0.07^{b}	0.03 ± 0.01^{a}	0.02 ± 0.01^{a}	0.02 ± 0.00^{a}	0.01 ± 0.00^{a}	0.02 ± 0.02^{a}	0.01 ± 0.01^{a}	0.01 ± 0.00^{a}
Pb^{2+}, mg l^{-1}	0.51 ± 0.25^{bc}	0.16 ± 0.02^{a}	0.87 ± 0.06^{d}	0.16 ± 0.03^{a}	0.63 ± 0.15^{c}	0.60 ± 0.07^{c}	0.36 ± 0.03^{ab}	0.20 ± 0.01^{a}
Mn^{2+}, mg l^{-1}	0.05 ± 0.03^{a}	0.33 ± 0.25^{ab}	0.16 ± 0.21^{a}	0.57 ± 0.35^{b}	0.05 ± 0.03^{a}	0.04 ± 0.01^{a}	0.03 ± 0.02^{a}	0.15 ± 0.03^{a}
Fe^{2+}, mg l^{-1}	0.14 ± 0.04^{ab}	1.60 ± 0.27^{c}	0.19 ± 0.06^{ab}	2.72 ± 0.12^{d}	0.04 ± 0.03^{a}	0.19 ± 0.03^{ab}	0.31 ± 0.18^{b}	0.16 ± 0.02^{ab}
Cu^{2+}, mg l^{-1}	0.20 ± 0.11^{c}	0.11 ± 0.04^{abc}	0.14 ± 0.02^{abc}	0.06 ± 0.02^{a}	0.15 ± 0.04^{abc}	0.16 ± 0.05^{bc}	0.06 ± 0.03^{a}	0.08 ± 0.03^{ab}
Zn^{2+}, mg l^{-1}	0.20 ± 0.00^{b}	0.03 ± 0.02^{a}	0.05 ± 0.03^{a}	0.03 ± 0.02^{a}	0.02 ± 0.01^{a}	0.03 ± 0.01^{a}	0.23 ± 0.06^{b}	0.03 ± 0.01^{a}
Cr^{2+}, mg l^{-1}	0.17 ± 0.23^{a}	0.04 ± 0.02^{a}	0.04 ± 0.02^{a}	0.05 ± 0.04^{a}	0.14 ± 0.03^{a}	0.13 ± 0.04^{a}	0.08 ± 0.04^{a}	0.01 ± 0.01^{a}
Ni^{2+}, mg l^{-1}	0.08 ± 0.04^{ab}	0.14 ± 0.03^{c}	0.35 ± 0.04^{e}	0.44 ± 0.02^{f}	0.05 ± 0.02^{a}	0.04 ± 0.02^{a}	0.13 ± 0.02^{bc}	0.29 ± 0.05^{d}

Superscripts with the same letters down the column were not significantly different at $p < 0.05$.

Drinking-water supply policy needs to clearly state (1) the requirements for water sources and resources protection; (2) the need for appropriate treatment, preventive maintenance within distribution systems; and (3) the requirements to support water safety after collection from communal sources (WHO, 2006).

Levels of in-situ parameters: None of the ranges of temperature exceeded the limits (WHO, 2003; NIS 554, 2007). Laderin and Ilaro that had slightly acidic pH, other estates had pH values that conformed to the limits (6.5 – 9.5). The pH ranges of 1st and 2nd dry seasons did not exceed the limits. The pH values of two estates water samples were less than 6.0 to indicate slight acidic condition, which may pose a risk for consumption due to metal toxicity to corroborate the affirmation that in a low pH condition, metals tend to go into solution thereby making them readily available for exposure (EPA, 2003) and Jarup (2003) had stated deleterious effects of heavy metals contaminations. Though there were high EC values in Ijebu-Ode River and Laderin in that decreasing order in the 1st dry season; in Laderin, Obada-Oko Ts, Arigbajo Well, Ijebu-Ode River in that decreasing order in the 1st wet season; in Ijebu-Ode River and Arigbajo Well in that decreasing order in the 2nd dry season; and Shagamu River and Ilaro in that decreasing order in the 2nd wet season, none of the ranges of EC exceeded the limit (1, 000 µS/ cm) (NIS 554, 2007).

Table 2: Results of the Water Quality in the 1st Wet Season (2018)

	Shagamu	Shagamu Rv	Ijebu-Ode	Ijebu-Ode Rv	Laderin	Arigbajo Well	Obada-Oko Ts	Ilaro
Temp, ^{O}C	23.89 ± 0.52^{a}	23.20 ± 2.02^{a}	22.24 ± 2.02^{a}	23.04 ± 2.15^{a}	21.17 ± 1.51^{a}	22.87 ± 0.53^{a}	22.37 ± 0.36^{a}	23.37 ± 0.36^{a}
pH	7.55 ± 0.20^{a}	8.80 ± 2.05^{ab}	10.41 ± 1.20^{bc}	10.11 ± 1.12^{bc}	11.81 ± 0.25^{c}	8.65 ± 1.08^{ab}	7.81 ± 0.53^{a}	9.11 ± 0.64^{ab}
EC, µS/ cm	84.11 ± 18.86^{ab}	58.87 ± 40.41^{a}	181.97 ± 103.23^{abc}	246.20 ± 206.45^{abc}	406.76 ± 213.82^{c}	267.60 ± 74.16^{abc}	331.83 ± 206.45^{bc}	85.63 ± 37.08^{ab}
TDS, mg l^{-1}	124.75 ± 2.73^{a}	139.42 ± 18.88^{a}	144.08 ± 45.31^{a}	135.33 ± 31.52^{a}	130.08 ± 35.36^{a}	112.58 ± 24.27^{a}	119.00 ± 25.90^{a}	107.92 ± 16.63^{a}
Total Hardness, mg l^{-1}	35.00 ± 17.50^{ab}	23.92 ± 5.35^{a}	134.17 ± 2.02^{f}	44.92 ± 2.02^{bc}	79.92 ± 10.55^{d}	115.50 ± 7.63^{e}	75.83 ± 8.27^{d}	57.17 ± 9.64^{c}
Total Acidity, mg l^{-1}	32.17 ± 0.45^{b}	41.42 ± 2.02^{cd}	11.67 ± 2.67^{a}	46.67 ± 2.67^{e}	38.91 ± 1.00^{c}	82.89 ± 2.83^{f}	42.70 ± 0.35^{d}	49.64 ± 0.61^{e}
Total Alkalinity, mg l^{-1}	4.99 ± 0.23^{a}	7.78 ± 1.33^{b}	20.07 ± 0.44^{d}	14.88 ± 0.80^{c}	15.52 ± 0.73^{c}	15.17 ± 1.23^{c}	15.167 ± 2.67^{c}	6.36 ± 0.19^{ab}
Nitrate, NO_3^-, mg l^{-1}	5.80 ± 0.79	6.31 ± 0.54^{a}	6.54 ± 0.37^{a}	6.54 ± 0.32^{a}	6.01 ± 0.61^{a}	6.36 ± 0.39^{a}	5.78 ± 0.86^{a}	6.57 ± 0.29^{a}
Sulphate, SO_4^{2-}, mg l^{-1}	7.93 ± 0.40^{d}	10.56 ± 0.06^{e}	7.10 ± 0.75^{cd}	1.98 ± 0.08^{b}	6.16 ± 0.57^{c}	0.75 ± 0.11^{a}	6.40 ± 0.57^{c}	6.99 ± 1.08^{cd}
Phosphate, PO_4^{3-}, mg l^{-1}	0.23 ± 0.05^{ab}	0.43 ± 0.07^{b}	0.23 ± 0.04^{ab}	0.43 ± 0.30^{b}	0.07 ± 0.04^{a}	0.04 ± 0.02^{a}	0.06 ± 0.04^{a}	0.37 ± 0.19^{b}
Chloride, Cl^-, mg l^{-1}	36.17 ± 1.46^{a}	38.49 ± 0.70^{ab}	90.77 ± 5.06^{e}	45.56 ± 1.59^{b}	68.83 ± 8.63^{c}	77.82 ± 2.05^{d}	78.67 ± 4.79^{d}	38.03 ± 3.16^{ab}
Ca^{2+}, mg l^{-1}	0.60 ± 0.62^{a}	0.55 ± 0.23^{a}	6.77 ± 0.86^{d}	0.32 ± 0.03^{a}	2.59 ± 0.88^{b}	4.80 ± 0.75^{c}	1.09 ± 0.29^{a}	1.09 ± 0.12^{a}
Mg^{2+}, mg l^{-1}	0.32 ± 0.05^{a}	0.75 ± 0.34^{ab}	8.33 ± 0.51^{e}	0.90 ± 0.11^{bc}	1.02 ± 0.12^{bc}	5.23 ± 0.05^{d}	1.36 ± 0.15^{c}	1.18 ± 0.12^{bc}
Na^{+}, mg l^{-1}	0.77 ± 0.15^{bc}	0.69 ± 0.26^{abc}	0.21 ± 0.14^{a}	0.64 ± 0.40^{abc}	0.95 ± 0.46^{c}	0.71 ± 0.21^{abc}	0.24 ± 0.07^{ab}	0.57 ± 0.30^{abc}
Cd^{2+}, mg l^{-1}	0.16 ± 0.14^{b}	0.03 ± 0.02^{a}	0.02 ± 0.00^{a}	0.03 ± 0.01^{a}	0.05 ± 0.03^{a}	0.04 ± 0.00^{a}	0.06 ± 0.02^{a}	0.02 ± 0.00^{a}
Pb^{2+}, mg l^{-1}	0.99 ± 0.48^{bc}	1.69 ± 0.11^{d}	1.22 ± 0.29^{c}	0.69 ± 0.06^{ab}	1.16 ± 0.14^{c}	0.32 ± 0.05^{a}	0.32 ± 0.04^{a}	0.38 ± 0.02^{a}
Mn^{2+}, mg l^{-1}	0.10 ± 0.06^{a}	0.30 ± 0.41^{a}	0.09 ± 0.05^{a}	0.06 ± 0.03^{a}	0.07 ± 0.01^{a}	1.09 ± 0.68^{b}	0.64 ± 0.49^{ab}	0.28 ± 0.59^{a}
Fe^{2+}, mg l^{-1}	0.27 ± 0.08^{ab}	0.37 ± 0.11^{ab}	0.08 ± 0.05^{a}	0.59 ± 0.35^{b}	0.37 ± 0.06^{ab}	5.24 ± 0.23^{d}	3.08 ± 0.53^{c}	0.31 ± 0.03^{ab}
Cu^{2+}, mg l^{-1}	0.38 ± 0.22^{c}	0.28 ± 0.04^{abc}	0.28 ± 0.08^{abc}	0.12 ± 0.06^{a}	0.31 ± 0.10^{bc}	0.12 ± 0.03^{a}	0.21 ± 0.08^{abc}	0.16 ± 0.5^{ab}
Zn^{2+}, mg l^{-1}	0.39 ± 0.00^{b}	0.10 ± 0.07^{a}	0.03 ± 0.02^{a}	0.45 ± 0.11^{b}	0.05 ± 0.02^{a}	0.06 ± 0.04^{a}	0.06 ± 0.04^{a}	0.06 ± 0.02^{a}
Cr^{2+}, mg l^{-1}	0.33 ± 0.05^{a}	0.07 ± 0.04^{a}	0.28 ± 0.05^{a}	0.16 ± 0.08^{a}	0.25 ± 0.07^{a}	0.10 ± 0.07^{a}	0.08 ± 0.04^{a}	0.03 ± 0.01^{a}
Ni^{2+}, mg l^{-1}	0.15 ± 0.08^{ab}	0.68 ± 0.07^{e}	0.10 ± 0.04^{a}	0.25 ± 0.04^{bc}	0.07 ± 0.03^{a}	0.85 ± 0.04^{f}	0.27 ± 0.06^{c}	0.57 ± 0.11^{d}

Superscripts with the same letters down the column were not significantly different at $p < 0.05$.

Presence of some metallic ore materials in the environmental components could influence high electrical conductivity (EC) (Ayodele and Aturamu, 2011). The ranges of TDS of all the available water samples were lower than the limits (500 mg l^{-1}), high value of total dissolved solids (TDS) in water can lead to gastro – intestinal irritation and cause staining on clothes when washed with (Ayodele and Aturamu, 2011).

Levels of chemical parameters: The two standards had no values to compare total hardness total acidity and alkalinity with; alkalinity is caused by HCO_3^-, CO_3^- and OH^- components in supplied water supply either raw or treated. However, alkalinity is not a significant parameter because variation of concentration (56 to 125mg/ L) is expected while higher values are still tolerated in the water supply (Dezuane, 1996).

Though there were high total hardness values in Shagamu River and Arigbajo Well in that decreasing order from the 1st wet season and also in Ilaro and Shagamu River in that decreasing order when compared with NIS 554 (2007) limit: 150 mg l^{-1}, the total hardness ranges of values were lower than the limits (500 mg l^{-1}). The hardness of the water may occur due to the high levels of calcium ions (Ca^{2+}), magnesium ions (Mg^{2+}) and chloride (Cl^-) (Ayodele and Aturamu, 2011).

Levels of anions components of the water samples: Though the ranges of values of nitrate in all the water samples exceeded limits set by WHO (2003) (3.00 mg l^{-1}), they were lower than limits set by NIS 554 (2007) (50.00 mg l^{-1}). Some traces of nitrate **(**NO_3^-) observed in the water samples could occur from application of artificial fertilizer and waste dump sites, which may in turn get leached and percolated into the soil and pollute the water (Tredoux *et al.,* 2000).

Nitrates are generally formed naturally in the soil by the microbial degradation of nitrogenous organic material such as proteins. The NO_3^- content for most water is not generally related to any geological formation and if in excess causes blue baby syndrome. Nitrogen fertilizers usage can be a problem where agriculture is increasingly practised.

Table 3: Results of the Water Quality in the 2nd Dry Season (2019)

	Shagamu	Shagamu Rv	Ijebu-Ode	Ijebu-Ode Rv	Laderin	Arigbajo Well	Obada-Oko Ts	Ilaro
Temp, ^{O}C	29.02 ± 0.12^{f}	25.45 ± 0.16^{b}	28.98 ± 0.28^{f}	24.82 ± 0.40^{a}	27.62 ± 0.21^{d}	26.74 ± 0.26^{c}	27.58 ± 0.42^{d}	28.11 ± 0.16^{e}
pH	5.86 ± 0.31^{a}	8.65 ± 0.02^{cd}	7.29 ± 0.48^{b}	9.00 ± 0.28^{d}	7.89 ± 1.27^{bc}	5.83 ± 0.01^{a}	6.94 ± 0.59^{b}	7.33 ± 0.58^{b}
EC, µS/ cm	51.38 ± 11.12^{a}	99.55 ± 78.46^{ab}	64.23 ± 29.43^{ab}	308.28 ± 19.27^{c}	122.03 ± 22.25^{b}	250.48 ± 38.54^{c}	44.96 ± 11.12^{a}	83.49 ± 11.12^{ab}
TDS, mg l^{-1}	77.00 ± 1.60^{bc}	100.10 ±6.06^{d}	65.45 ± 8.74^{abc}	94.50 ± 7.27^{d}	58.80 ± 10.96^{a}	80.15 ± 1.60^{c}	64.40 ± 10.52^{ab}	65.80 ± 11.03^{abc}
Total Hardness, mg l^{-1}	40.83 ± 6.88^{c}	54.17 ± 5.91^{d}	32.08 ± 1.44^{bc}	82.50 ± 5.45^{e}	57.08 ± 7.53^{d}	95.83 ± 1.44^{f}	17.08 ± 3.82^{a}	25.00 ± 12.50^{ab}
Total Acidity, mg l^{-1}	35.46 ± 0.44^{e}	30.50 ± 0.25^{d}	33.33 ± 1.91^{e}	59.21 ± 2.02^{f}	27.79 ± 0.71^{c}	8.33 ± 1.91^{a}	29.58 ± 1.44^{cd}	22.98 ± 0.32^{b}
Total Alkalinity, mg l^{-1}	4.55 ± 0.14^{ab}	10.83 ± 1.91^{c}	10.63 ± 0.57^{c}	10.83 ± 0.88^{c}	11.08 ± 0.52^{c}	14.33 ± 0.31^{d}	5.55 ± 0.95^{b}	3.57 ± 0.16^{a}
Nitrate, NO_3^-, mg l^{-1}	4.70 ± 0.21^{a}	4.13 ± 0.62^{a}	4.67 ± 0.23^{a}	4.55 ± 0.28^{a}	4.30 ± 0.44^{a}	4.67 ± 0.27^{a}	4.51 ± 0.39^{a}	4.14 ± 0.57^{a}
Sulphate, SO_4^{2-}, mg l^{-1}	5.00 ± 0.77^{cd}	4.57 ± 0.40^{c}	1.42 ± 0.06^{b}	0.54 ± 0.08^{a}	4.40 ± 0.41^{c}	5.07 ± 0.54^{cd}	7.55 ± 0.04^{e}	5.66 ± 0.29^{d}
Phosphate, PO_4^{3-}, mg l^{-1}	0.26 ± 0.14^{b}	0.04 ± 0.03^{a}	0.30 ± 0.22^{b}	0.03 ± 0.01^{a}	0.05 ± 0.03^{a}	0.17 ± 0.03^{ab}	0.31 ± 0.05^{b}	0.16 ± 0.03^{ab}
Chloride, Cl^-, mg l^{-1}	27.17 ± 2.25^{ab}	56.20 ± 3.42^{d}	32.54 ± 1.13^{b}	55.59 ± 1.46^{d}	49.17 ± 6.17^{c}	64.83 ± 3.62^{e}	27.50 ± 0.50^{ab}	25.83 ± 1.04^{a}
Ca^{2+}, mg l^{-1}	0.70 ± 0.08^{a}	0.71 ± 0.19^{a}	0.20 ± 0.02^{a}	3.11 ± 0.48^{c}	1.68 ± 0.57^{b}	4.38 ± 0.56^{d}	0.36 ± 0.15^{a}	0.39 ± 0.40^{a}
Mg^{2+}, mg l^{-1}	0.76 ± 0.08^{bc}	0.88 ± 0.10^{c}	0.58 ± 0.07^{bc}	3.39 ± 0.33^{d}	0.66 ± 0.08^{bc}	5.40 ± 0.33^{e}	0.48 ± 0.22^{ab}	0.21 ± 0.03^{a}
Na^{+}, mg l^{-1}	0.37 ± 0.19^{abc}	0.16 ± 0.04^{ab}	0.42 ± 0.26^{abc}	0.46 ± 0.14^{abc}	0.61 ± 0.30^{c}	0.14 ± 0.09^{a}	0.45 ± 0.17^{abc}	0.50 ± 0.10^{bc}
Cd^{2+}, mg l^{-1}	0.01 ± 0.00^{a}	0.04 ± 0.01^{a}	0.02 ± 0.01^{a}	0.03 ± 0.00^{a}	0.03 ± 0.02^{a}	0.01 ± 0.00^{a}	0.02 ± 0.01^{a}	0.10 ± 0.09^{b}
Pb^{2+}, mg l^{-1}	0.25 ± 0.01^{a}	0.20 ± 0.03^{a}	0.44 ± 0.04^{ab}	0.21 ± 0.03^{a}	0.75 ± 0.09^{c}	0.79 ± 0.19^{c}	1.09 ± 0.07^{d}	0.64 ± 0.31^{bc}
Mn^{2+}, mg l^{-1}	0.18 ± 0.04^{a}	0.42 ± 0.32^{ab}	0.04 ± 0.02^{a}	0.71 ± 0.44^{b}	0.05 ± 0.01^{a}	0.06 ± 0.03^{a}	0.20 ± 0.26^{a}	0.07 ± 0.04^{a}
Fe^{2+}, mg l^{-1}	0.20 ± 0.02^{ab}	2.00 ± 0.34^{c}	0.38 ± 0.02^{b}	3.40 ± 0.15^{d}	0.24 ± 0.04^{ab}	0.05 ± 0.03^{a}	0.24 ± 0.07^{ab}	0.18 ± 0.05^{ab}
Cu^{2+}, mg l^{-1}	0.11 ± 0.03^{ab}	0.14 ± 0.05^{abc}	0.08 ± 0.04^{a}	0.08 ± 0.02^{a}	0.20 ± 0.06^{bc}	0.18 ± 0.05^{abc}	0.18 ± 0.02^{abc}	0.25 ± 0.14^{c}
Zn^{2+}, mg l^{-1}	0.04 ± 0.01^{a}	0.04 ± 0.03^{a}	0.29 ± 0.07^{b}	0.04 ± 0.03^{a}	0.03 ± 0.01^{a}	0.02 ± 0.01^{a}	0.06 ± 0.05^{a}	0.25 ± 0.00^{b}
Cr^{2+}, mg l^{-1}	0.02 ± 0.01^{a}	0.05 ± 0.03^{a}	0.11 ± 0.05^{a}	0.06 ± 0.05^{a}	0.16 ± 0.05^{a}	0.18 ± 0.03^{a}	0.05 ± 0.03^{a}	0.22 ± 0.29^{a}
Ni^{2+}, mg l^{-1}	0.37 ± 0.07^{d}	0.18 ± 0.04^{c}	0.16 ± 0.03^{bc}	0.55 ± 0.03^{f}	0.05 ± 0.02^{a}	0.06 ± 0.03^{a}	0.44 ± 0.04^{e}	0.10 ± 0.05^{ab}

Superscripts with the same letters down the column were not significantly different at $p < 0.05$.

Table 4: Results of the Water Quality in the 2nd Wet Season (2019)

	Shagamu	Shagamu Rv	Ijebu-Ode	Ijebu-Ode Rv	Laderin	Arigbajo Well	Obada-Oko Ts	Ilaro
Temp, ^{O}C	23.60 ± 0.26^{f}	19.63 ± 0.38^{a}	23.63 ± 0.12^{f}	20.23 ± 0.15^{b}	22.27 ± 0.41^{d}	22.77 ± 0.15^{e}	22.30 ± 0.20^{d}	21.47 ± 0.25^{c}
pH	9.84 ± 0.65^{b}	12.15 ± 0.37^{d}	7.90 ± 0.42^{a}	11.67 ± 0.02^{cd}	9.37 ± 0.80^{b}	9.90 ± 0.78^{b}	10.65 ± 1.71^{bc}	7.88 ± 0.02^{a}
EC, µS/ cm	103.98 ± 47.65^{ab}	499.12 ± 31.20^{c}	83.19 ± 18.01^{a}	161.2 ± 127.0^{ab}	72.79 ± 18.01^{a}	135.18 ± 18.01^{ab}	197.57 ± 36.02^{b}	405.54 ± 62.39^{c}
TDS, mg l^{-1}	106.00 ± 14.16^{abc}	153.00 ± 11.78^{d}	124.67 ± 2.60^{bc}	162.07 ± 9.81^{d}	104.27 ± 17.03^{ab}	106.53 ± 17.86^{abc}	95.20 ± 17.75^{a}	129.77 ± 2.60^{c}
Total Hardness, mg l^{-1}	49.54 ± 2.23^{bc}	127.38 ± 8.41^{e}	63.05 ± 10.63^{c}	83.63 ± 9.12^{d}	26.38 ± 5.90^{a}	38.60 ± 19.30^{ab}	88.14 ± 11.63^{d}	147.97 ± 2.23^{f}
Total Acidity, mg l^{-1}	51.47 ± 2.95^{e}	91.42 ± 3.13^{f}	54.75 ± 0.68^{e}	47.09 ± 0.39^{d}	45.68 ± 2.23^{cd}	35.48 ± 0.50^{b}	42.91 ± 1.10^{c}	12.87 ± 2.95^{a}
Total Alkalinity, mg l^{-1}	16.41 ± 0.88^{c}	16.73 ± 1.36^{c}	7.02 ± 0.21^{ab}	16.73 ± 2.95^{c}	8.58 ± 1.47^{b}	5.51 ± 0.25^{a}	17.11 ± 0.80^{c}	22.13 ± 0.49^{d}
Nitrate, NO_3^-, mg l^{-1}	7.21 ± 0.35^{a}	7.02 ± 0.43^{a}	6.37 ± 0.95^{a}	7.25 ± 0.32^{a}	6.96 ± 0.60^{a}	6.39 ± 0.87^{a}	6.63 ± 0.68^{a}	7.21 ± 0.41^{a}
Sulphate, SO_4^{2-}, mg l^{-1}	2.19 ± 0.09^{b}	0.83 ± 0.12^{a}	7.71 ± 1.20^{cd}	7.06 ± 0.62^{c}	11.65 ± 0.07^{e}	8.74 ± 0.44^{d}	6.79 ± 0.63^{c}	7.83 ± 0.83^{cd}
Phosphate, PO_4^{3-}, mg l^{-1}	0.47 ± 0.34^{b}	0.05 ± 0.02^{a}	0.41 ± 0.21^{b}	0.06 ± 0.05^{a}	0.48 ± 0.08^{b}	0.25 ± 0.05^{ab}	0.08 ± 0.04^{a}	0.26 ± 0.04^{ab}
Chloride, Cl^-, mg l^{-1}	50.24 ± 1.75^{b}	85.83 ± 2.23^{d}	41.95 ± 3.48^{ab}	86.77 ± 5.28^{d}	42.45 ± 0.77^{ab}	39.89 ± 1.61^{a}	75.91 ± 9.52^{c}	100.10 ± 5.59^{e}
Ca^{2+}, mg l^{-1}	0.29 ± 0.03^{a}	4.35 ± 0.67^{c}	0.99 ± 0.11^{a}	0.99 ± 0.27^{a}	0.50 ± 0.21^{a}	0.54 ± 0.56^{a}	2.35 ± 0.80^{b}	6.14 ± 0.78^{d}
Mg^{2+}, mg l^{-1}	0.82 ± 0.10^{bc}	4.74 ± 0.46^{d}	1.07 ± 0.11^{bc}	1.23 ± 0.12^{c}	0.68 ± 0.31^{ab}	0.29 ± 0.04^{a}	0.92 ± 0.11^{bc}	7.55 ± 0.47^{e}
Na^{+}, mg l^{-1}	0.58 ± 0.36^{abc}	0.65 ± 0.18^{abc}	0.52 ± 0.27^{abc}	0.22 ± 0.06^{ab}	0.62 ± 0.24^{abc}	0.69 ± 0.14^{bc}	0.86 ± 0.42^{d}	0.19 ± 0.12^{a}
Cd^{2+}, mg l^{-1}	0.02 ± 0.01^{a}	0.03 ± 0.00^{a}	0.02 ± 0.00^{a}	0.05 ± 0.02^{a}	0.03 ± 0.02^{a}	0.15 ± 0.12^{b}	0.04 ± 0.03^{a}	0.02 ± 0.00^{a}
Pb^{2+}, mg l^{-1}	0.62 ± 0.05^{ab}	0.29 ±0.04^{a}	0.34 ± 0.02^{a}	0.29 ± 0.04^{a}	1.53 ± 0.10^{d}	0.90 ± 0.43^{bc}	1.06 ± 0.13^{c}	1.11 ± 0.27^{c}
Mn^{2+}, mg l^{-1}	0.06 ± 0.03^{a}	0.99 ± 0.61^{b}	0.26 ± 0.05^{a}	0.58 ± 0.44^{ab}	0.27 ± 0.37^{a}	0.09 ± 0.06^{a}	0.06 ± 0.01^{a}	0.08 ± 0.04^{a}
Fe^{2+}, mg l^{-1}	0.54 ± 0.31^{b}	4.75 ± 0.21^{d}	0.28 ± 0.03^{ab}	2.79 ± 0.48^{c}	0.34 ± 0.10^{ab}	0.25 ± 0.08^{ab}	0.33 ± 0.05^{ab}	0.08 ± 0.04^{a}
Cu^{2+}, mg l^{-1}	0.11 ± 0.05^{a}	0.11 ± 0.03^{a}	0.15 ± 0.04^{ab}	0.19 ± 0.07^{abc}	0.25 ± 0.04^{abc}	0.34 ± 0.20^{c}	0.28 ± 0.09^{bc}	0.26 ± 0.07^{abc}
Zn^{2+}, mg l^{-1}	0.41 ± 0.10^{b}	0.05 ± 0.04^{a}	0.06 ± 0.02^{a}	0.05 ± 0.04^{a}	0.09 ± 0.06^{a}	0.35 ± 0.00^{b}	0.05 ± 0.02^{a}	0.03 ± 0.02^{a}
Cr^{2+}, mg l^{-1}	0.15 ± 0.07^{a}	0.09 ± 0.06^{a}	0.02 ± 0.01^{a}	0.07 ± 0.04^{a}	0.06 ± 0.04^{a}	0.30 ± 0.04^{a}	0.23 ± 0.06^{a}	0.25 ± 0.04^{a}
Ni^{2+}, mg l^{-1}	0.23 ± 0.04^{bc}	0.77 ± 0.04^{f}	0.51 ± 0.10^{d}	0.25 ± 0.05^{c}	0.62 ± 0.06^{e}	0.13 ± 0.07^{ab}	0.06 ± 0.03^{a}	0.09 ± 0.04^{a}

Superscripts with the same letters down the column are not significantly different at $p < 0.05$.

These fertilizers would influence the concentration of NO_3^- in groundwater, resulting in high nitrate levels in underground water sources and methemoglobinemia, the life threatening "blue baby" syndrome, in very young children that has constituted a significant problem in parts of rural Eastern Europe (Yassi *et al.,* 2001). The ranges of values of sulphate were lower than the standards (100.00 mg l^{-1}) (WHO, 2003) and (250.00 mg l^{-1}) (NIS 554, 2007). Traces of Sulphate ions or concentration (SO_4^{2-}) in the water sample are possible from improper disposal of sewage and refuse, though may occur in natural unaffected water which consists of up to 50mg l^{-1} (Ayodele and Aturamu, 2011). The ranges of values of chloride were lower than the standards (250.00 mg l^{-1}) (WHO, 2003; NIS 554, 2007). Sources of Chloride (Cl^-) in water include weathering from rocks containing chlorides, fertilizers, animal wastes and chloride concentration is possible from influx of meteoric water, weathering and subsequent release of ions from the underlying basement rocks (Ayodele and Aturamu, 2011). Possible sources of bicarbonate ion (CO_3^{2-}) in water are CO_2 of the air and soil organic matter. However, its concentration in water relies on the water pH. The source of HCO_3^- of the study area can be associated with the influence of carbon dioxide from influx water (Tijani, 1994).

Levels of cations components of the water samples: Mineral elements (Ca, Mg, Na, P and K) are associated with various physiological and biochemical activities in the body systems of man (Fu *et al.*, 2004; Raju *et al.*

2006). The two standards (WHO, 2003; NIS 554, 2007) had no values to compare calcium (Ca) concentrations with, though Ca helps to reduce the blood glucose content by using insulin secreted by K (Raju *et al.* 2006). The high value of Ca may be as a result of its abundance in the earth crust. The National Foods and Drugs Administration Control (NAFDAC) maximum allowed limits for calcium ion is 75mg l^{-1} (Ayodele and Aturamu, 2011). All but Shagamu water sample in the 1^{st} dry season had magnesium (Mg) values that exceeded the NIS 554 (2007) standard (0.20 mg l^{-1}). The values of Mg in Shagamu in the 1^{st} wet season, Obada-Oko Ts and Ilaro in the 2^{nd} dry season, and Arigbajo Well were lower than the WHO (2003) standard (0.50 mg l^{-1}). However, the vales of ranges of Mg concentrations exceeded the limits: 0.50 mg l^{-1} (WHO, 2003) and 0.20 mg l^{-1} (NIS 554, 2007). The high concentration of Mg in underground water could be traced to the leaching of minerals such as biotite, olivine, pyroxene or clay minerals as reiterated by earlier works (Elueze *et al.,* 2001; Ayodele and Aturamu, 2011). Also, excessive concentration of magnesium in domestic water has cathartic and direct effect when is associated with the level of sulphates (Ayodele and Aturamu, 2011). The ranges of values of sodium (Na) were lower than the standards (20.00 mg l^{-1}) (WHO, 2003) and (200.00 mg l^{-1}) (NIS 554, 2007). The high concentration of Na in environmental samples might be as a result of close contact with or relationship between the bedrocks and it is known as an abundant compound which is very soluble. Though high Na concentration is detrimental to human health causing heart disease (voshoey, 1985 *cited in* Ayodele and Aturamu, 2011), the stipulated level of Na in drinking water is 200mg/ L. Blood pressure could be reduced by low Na diet (Soypacaci *et al.,* 2013). The ranges of values of cadmium (Cd) were lower than the NIS 554 (2007) standard (0.003 mg l^{-1}) but exceeded the limits of WHO (2003) standard (0.01 – 0.04 mg l^{-1}). The ranges of values of lead (Pb) exceeded the limits (0.01 – 0.05 mg l^{-1}) (WHO, 2003; NIS 554, 2007). Use of Pb piping materials and plumbing fixtures may cause high levels of lead in piped water. Accumulation of Pb occurs in the skeleton, especially in bone marrow, it is the most recognized toxic environmental pollutant. It is a neurotoxin and causes behavioral abnormalities, retarded intelligence and mental development (Tokalioglu, 2012). Some elements are thought to have dietary benefit and toxic effect based on their concentrations and forms of availability, such elements include Mn, Fe, Cu, Zn, Cr, Ni, Co, Se, B, Mo and Li (Olujimi *et al.,* 2014).

Table 5: Comparison of Ranges of Values of the Water Parameters with Potable Water Standards

	1^{st} Dry Season	1^{st} Wet Season	2^{nd} Dry Season	2^{nd} Wet Season	WHO, 2003	NIS 554:2007
Temp, ^{O}C	23.63 - 27.63	21.17 - 23.89	24.82 - 29.02	19.63 - 23.63	40.00	Ambient
pH	5.56 - 8.23	7.55 - 11.81	5.83 - 9.00	7.88 - 12.15	6.5 – 9.5	6.5 – 8.5
EC, µS/ cm	42.82 - 293.60	58.87 - 406.76	51.38 - 308.28	72.79 - 499.12		1, 000.00
TDS, mg l^{-1}	56.00 - 95.33	107.92 - 144.08	58.80 - 100.10	95.20 - 162.07	500.00	500.00
Hardness, mg l^{-1}	13.67 - 76.67	23.92 - 134.17	17.08 - 95.83	26.38 - 147.97	500.00	150.00
Acidity, mg l^{-1}	6.67 - 28.37	11.67 - 82.89	8.33 - 59.21	12.87 - 91.42		
Alkalinity, mg l^{-1}	2.85 - 11.47	4.99 - 20.07	3.57 - 14.33	5.51 - 22.13		
Nitrate, NO_3^-, mg l^{-1}	3.30 - 3.76	5.78 - 6.57	4.13 - 4.70	6.37 - 7.25	3.00	50.00
Sulphate, SO_4^{2-}, mg l^{-1}	1.13 - 6.04	0.75 - 10.56	0.54 - 7.55	0.83 - 11.66	250.00	100.00
Phosphate, PO_4^{3-}, mg l^{-1}	0.02 - 0.25	0.04 - 0.43	0.03 - 0.31	0.05 - 0.48		
Chloride, Cl^-, mg l^{-1}	20.67 - 51.87	36.17 - 90.77	25.83 - 64.83	39.89 - 100.10	< 250.00	250.00
Ca^{2+}, mg l^{-1}	0.16 - 3.51	0.32 - 6.77	0.20 - 4.38	0.29 - 6.14		
Mg^{2+}, mg l^{-1}	0.17 - 4.32	0.32 - 8.33	0.21 - 5.40	0.29 - 7.55	0.50	0.20
Na^{+}, mg l^{-1}	0.11 - 0.49	0.21 - 0.95	0.14 - 0.61	0.19 - 0.86	20.00	200.00
Cd^{2+}, mg l^{-1}	0.01 - 0.08	0.02 - 0.16	0.01 - 0.04	0.02 - 0.15	0.01 – 0.04	0.003
Pb^{2+}, mg l^{-1}	0.16 - 0.87	0.32 - 1.69	0.20 - 0.79	0.29 - 1.53	0.01 - 0.05	0.01
Mn^{2+}, mg l^{-1}	0.03 - 0.57	0.06 - 1.69	0.04 - 0.71	0.06 - 0.99	0.1 – 0.5	0.30
Fe^{2+}, mg l^{-1}	0.04 - 2.72	0.08 - 5.24	0.05 - 3.40	0.08 - 4.75	(1.0 – 3.0)	0.20 – 0.30
Cu^{2+}, mg l^{-1}	0.06 - 0.20	0.12 - 0.38	0.08 - 0.25	0.11 - 0.34	2.00	1.00
Zn^{2+}, mg l^{-1}	0.02 - 0.23	0.03 - 0.45	0.02 - 0.29	0.03 - 0.41	3.00	3.00
Cr^{2+}, mg l^{-1}	0.01 - 0.17	0.03 - 0.33	0.02 - 0.22	0.02 - 0.30	0.05	0.05
Ni^{2+}, mg l^{-1}	0.04 - 0.44	0.07 - 0.85	0.05 - 0.55	0.06 - 0.77	0.02	0.02

The values of manganese (Mn) in the 1^{st} dry season except in Ijebu-Ode Rivers (0.57 ± 0.35 mg l^{-1}) were lower than the limits (0.10 – 0.50 mg l^{-1}) (WHO, 2003; NIS 554, 2007). The value of Mn in the 1^{st} wet season in Arigbajo Well (1.09 ± 0.68 mg l^{-1}) and Obada-Oko (0.64 ± 0.49 mg l^{-1}) exceeded the limits (0.10 – 0.50 mg l^{-1}). The value of Mn in the 2^{nd} dry season except in Ijebu-Ode Rivers (0.71 ± 0.44 mg l^{-1}) were lower than the limits (0.10 – 0.50 mg l^{-1}). The value of Mn in the 2^{nd} wet season in Shagamu River (0.99 ± 0.61 mg l^{-1}) and Ijebu-Ode River (0.58 ± 0.44 mg l^{-1}) exceeded the limits (0.10 – 0.50 mg l^{-1}). However, the range of Mn exceeded the limits (0.10 – 0.50 mg l^{-1}). Thus, the range of concentrations of the selected (toxic and heavy) metals in all the analyzed water samples exceeded the compared standards (WHO, 2003; NIS 554, 2007). The observation corroborated the assertion that groundwater quality differs from place to place and this may affect water suitability for consumption (Jain *et al.,* 1995). Adapting practices such as organic farming and integrated pest management could prone waterways to contamination (Scheierling 1995).

Conclusion: The concentration ranges of the assessed metals (toxic: Cd and Pb, and heavy: Mn, Fe, Cu, Zn, Cr and Ni) showed that the standards were exceeded, making the water samples not fit for human consumption. The housing estates need water treatment plant to get potable water. There is need to recycle chemical containers, minimise waste stockpiling and prevent chemicals into waterways.

REFERENCES

Amujo, BT; Towolawi, AT; Adeofun, CO; Oguntoke, O; Babalola, OA; Ojekunle, ZO (2019). Influence of Seasonal Variation on Soil Chemical Contents in Selected Housing Estates, Ogun State. *Afr. J. Agric. Tech. Env.* 8(2): 24-38.

Ako, BD; Adeniyi, FI; Adepoju, JF (1990). Statistical tests and chemical, quality of shallow groundwater from a metamorphic terrain Ile-Ife / Modakeke, S. W., Nigeria. *J. Afr. Earth Sc.,* 10 (3): 602-613.

Ayodele, OS; Aturamu, AO (2011). Portability status of some hand dug wells in Ekiti state, southwestern Nigeria. *Int. J. Sc. Tech.,* 1 (2): 102 - 109.

Davis, SN; Deweist, RJM (1966. Hydrogeology, John wiley and Sons, New York, Pp 463 Decree on the Ecological Network, 2010.

Dezuane, J (1996). Handbook of drinking water quality 1 John Dezuane- 2nd ed. Copyright 1997 by John wiley & Sons Incorporated. John Dezuane p.k. Ha.

Elenkova, NG; Tsoneva, RA; Nedelcheva, TK (1980). New turbidimetric method for determination of sulphate. Talanta 27: 67– 68.

EPA (Environmental Protection Agency) (2003). Environmental chemistry, transport and fate. http://www.epa.gov/raf/metalsframework/ pdfs/chaper3.pdf.

Fu, Z; Xie, M; Xie, Zhang, Z; Guo, L (2004). Determination of inorganic elements in plantago by ICP-AES, *Spectrosc. Spect. Anal.* 24 (6): 737–740.

Jain, CK; Bhatia, KK; Vijay, T (1995). Ground water quality monitoring and evaluation in and around Kakinada, Andhra Pradesh, Technical Report, CS (AR) 172, National Institute of Hydrology, Roorkee, pp. 1994-1995.

Jarup, L (2003). Hazards of heavy metal contamination. *Br. Med. Bul.,* 68 (1): 167-182.

Kinniburgh, DG; Smedley, PA (eds.) (2001). Arsenic contamination of groundwater in Bangladesh. BGS Technical Report WC/00/19. Keyworth, U.K.: British Geological Survey; Dhaka: Department of Public Health Engineering.

NIS (Nigerian Industrial Standard), (2000). NIS 554: 2007, Nigerian standard for drinking water quality. ICS 13.060.20. Price group D. Standards Organisation of Nigeria. Operational Headquarters. 13/ 14, Victoria Arobieke Street, Off Admiralty Way, Lekki Pennisula Scheme 1, Lekki, Lagos, Nigeria, pp. 1-30.

Oladeji, O; Adelowo, F; Abraham, OK (2016). Evaluation of Phosphate Level in Water Samples (Ogbomoso Rivers) Using UV-Visible Spectrophotometric Method. *Int. J. Sc. Res. Env. Sc.,* 4(4):102-108.

Olujimi, OO; Bamgbose, O; Arowolo, T; Steiner, O; Goessler, W (2014). Elemental profiles of herbal plants commonly used for cancer therapy in Ogun State, Nigeria. Part I. *Microchem. J.,* 117: 233–241.

Raju, GJ; Sarita, P; Murtya, GA; Kumar, MR; Reddy, BS; Charles, MJ; Lakshminarayana, S; Reddy, TS; Reddy, SB; Vijayan, SB (2006). Estimation of trace elements in some anti-diabetic medicinal plants using PIXE technique, *Appl. Radiat. Isot.* 64: 893–900.

Sawyer, CN; McCarty, PL; Parkin, GF (2000). Chemistry for Environmental Engineering 4th Edition. Tata McGraw-Hill Publishing Company Limited.

SESDPROC-111-R4, (2018). In Situ Water Quality Monitoring. SESDPROC-111-R4. Effective Date: March 14, 2018. Region 4, U.S. Environmental Protection Agency, Science and Ecosystem Support Division, Athens, Georgia, pp. 9.

Scheierling, S (1995). Overcoming Agricultural Pollution of Water: The Challenge of Integrating Agricultural and Environmental Policies in the European Union." Technical Paper 269, World Bank, Washington DC.

Soypacaci, Z; Sengul, S; Yıldız, EA; Keven, K; Kutlay, S; Erturk, S; Erbay, B (2013). Effect of daily sodium intake on post-transplant hypertension in kidney allograft recipients. *Transplant. Proc.* 45: 940–943.

Taiwo, AM; Towolawi, AT; Olanigan, AA; Olujimi, OO; Arowolo, TA (2015). Comparative Assessment of Groundwater Quality of Urban and Rural Areas in Nigeria. *Res. Pract. Wat. Qual. J., Chapter* 7: 180-191.

Tejuoso, OJ (2006). Wetland uses/dynamics for agricultural purposes and its health implications in lower Ogun river basin, Lagos, Nigeria" A technical report summated to International Development Research Centre (IDRC) (Ecosystem Approach to Human Health Team), pp. 20-22.

Tarrass, F; Benjelloun, M (2012). The effects of water shortages on health and human development. *Perspect. Public Health,* 132(5): 240-2444.

Tijani, MN (1994). Hydrogeochemical assessment of groundwater in Moro area, Kwara state, Nigeria. *Environ. Geo.* 24 (3): 194 – 202.

Tokalioglu, S (2012). Determination of trace elements in commonly consumed medicinal herbs by ICPMS and multivariate analysis, *Food Chem.* 134: 2504–2508.

Tredoux, G; Tana, AS; Engelbrecht, (2000). The increasing nitrate hazard in groundwater in the rural areas paper presented at Water institute, South African Conference, May, Sun City.

USEPA (U.S. Environmental Protection Agency) (2001). Method 1686 Nitrate/Nitrite-N in Water and Biosolids by Manual Colorimetry. EPA-821-R-01-005. U.S. Environmental Protection Agency Office of Water Office of Science and Technology Engineering and Analysis Division 1200 Pennsylvania Ave., NW Washington, DC, pp. 26.

Virgilio, A; Nóbrega, JA; Rêgo, JF; Gomes Neto, JA (2012). Evaluation of solid sampling highresolution continuum source graphite furnace atomic absorption spectrometry for direct determination of chromium in medicinal plants, *Spectrochim. Acta B*. 78: 58–61.

WHO (World Health Organisation) (1997). Health and Environment in Sustainable Development. Document WHO/EHG/97.8. Geneva: WHO.

WHO (World Health Organisation), (2003). Guidelines for Drinking Water Quality. 3rd ed. Geneva: WHO. http://www.who.int/water_sanitation_health/dwq / guidelines 3rd/en/. (WHO/SDE/WSH/03.04/88).

WHO and IPCS (World Health Organisation and International Programme on Chemical Safety). (2002). Global Assessment of the State of Science of Endocrine Disruptors. Document WHO/PCS/EDC/02.2. Geneva: WHO and the International Programme on Chemical Safety.

WWAP (United Nations World Water Assessment Programme), (2017). The United Nations World Water Development Report 2017. Wastewater: The Untapped Resource. Paris. ISBN 978-92-3-100201-4. Archived from the original on 8 April 2017

WHO (World Health Organization), (2006). Guidelines for the safe use of wastewater, excreta, and greywater. World Health Organization,
pp. 31. ISBN 9241546859. OCLC 71253096.

WHO (World Health Organisation), (2004). Guidelines for Drinking Water Quality, International Standards for Drinking Water Volume.1 Geneva W.H.O., pp. 130.

WHO (World Health Organisation), (2006). Guidelines for Drinking-Water Quality, First Addendum to Third Edition Volume 1 Recommendations – 3rd Edition, pp. 595.

Yassi, AL; Kjellstrom, T; DeKok, T; Guidotti, T (2001). Basic Environmental Health. New York: Oxford University Press, pp. 441.