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ABSTRACT

The quality of well-dug water for drinking and irrigation purposes must be measured as part of a sustainable groundwater analysis. The study aimed to assess water quality and to evaluate their usefulness for drinking and irrigation, using the Drinking Water Quality Index (DWQI) and Irrigation Water Quality Index (IWQI). To achieve this, standard methods were used for the determination of physicochemical parameters of the water samples, while using models (ESP, SSP, SAR, MAR, KR, TDS, and EC) to ascertain their suitability for drinking and irrigation. According to the findings, the determined Physico-chemical parameters were compared to standard limits and found desirable because they were within the guidelines. Low pH (6.4-7), total dissolved solids (106-130 mg/L), total hardness (42-56 mg/L), calcium (3.5-8.3 mg/L), magnesium (1.13.6 mg/L), nitrate (4.6-16 mg/L), chloride (1.8-3.1), and sulphate (14-15. mg/L) in the well samples were found to be the key cause of the low DWQI and IWQI value at these sites. The results also depicted that all the water samples are of exceptional quality (excellent).

Keywords: Well dug water sample, Physico-chemical parameters, irrigation, water quality, Akure

INTRODUCTION

One of the sustainable development goals (Goal 6) is to ensure the availability and sustainable management of water and sanitation for all by 2030 (Abulude and Oluwagbayide, 2018). The targets are: First, to achieve universal and equitable access to safe and affordable drinking water for all; second, to access adequate and equitable sanitation and hygiene for all; third to improve water quality by reducing pollution, eliminating dumping, and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater; fourth, implementing integrated water resources management at all levels; fifth, protecting and restoring water-related ecosystems; sixth,' expanding the international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, and lastly, Support and strengthen the participation of local communities in improving water and sanitation management (United Nations, 2020).

Water shortage is seen as a major stumbling block to intensifying agriculture sustainably to meet the food demands of a rapidly increasing human population (Tadesse et al., 2009). The world's two main non-renewable resources, soil, and water are under severe strain as a result of the rising human population, climate change due to increased greenhouse gas (GHG) emissions, and agricultural intensification, posing a significant challenge in producing enough food to meet current demand. According to Zaman et al. (2018), the current global population of 7.3 billion people is expected to rise to over 9 billion by 2050, with the bulk of this growth taking place in developing countries, the majority of which are already experiencing food shortages. If these human population growth estimates are right, a 70% increase in current agricultural productivity would be needed to produce enough food. In this context, global efforts are being made to increase the effectiveness of the water that will be used to boost irrigated crop production. In rain-fed agriculture, attempts are also being made to increase water harvesting and conservation (Zaman et al., 2018).

Since soluble salts affect soil structure, permeability, and aeration, water containing high concentrations of soluble salts may be harmful to many crops (Keller, 1978; Swaid and Issa, 2014). As a result, determining the quality of groundwater for irrigation purposes is critical. As a result, the need to assess the suitability of groundwater resources for drinking and irrigation is growing, as evidenced by the relatively large number of recent studies in this area (Peiyue et al., 2011; Jouyban, 2012). Groundwater suitability for agriculture and domestic use is primarily determined by site-specific water quality, with potential temporal fluctuations due to climatic conditions, as well as water residence time within aquifer materials and anthropogenic activities (Oladeji et al., 2012). Certain conditions, especially where sodium ions and other ions accumulate in the soil structure as a result of prolonged irrigation, can lead to degradation of soil physical properties, resulting in a reduction in crop yield.

A study has shown that residents of some areas have health issues such as cancer, fluorosis, and gastrointestinal discomfort (Sharma et al. 2017). Water quality must be monitored regularly to understand how it is worsening and to prepare remedial steps to avoid further damage. As a result, a physicochemical investigation of well-dug water samples was conducted in these three locations to better understand the evolving scenario of the water chemistry and to evaluate their usefulness for drinking and irrigation.

MATERIALS AND METHODS

Akure, Nigeria's capital, is situated at 7°15′0″ north latitude and 5°11′42″ east longitude (Figure 1) and has a population of over 350,000 people as of 2008. (Aribigbola, 2008). Table 1 lists the sites where well water samples were taken. The three water sources in this analysis were wells drilled only a few meters from the Ala River. This river flows through Akure city, which is on the outskirts of Akure metropolis, the capital of Ondo state, and is located at 90 41 N and 6031E. For the Akure community in particular and the Ondo metropolis in general, the Ala River is used for domestic use, agriculture, and industry (Mimiko, 2009).

Table 1: The Description of Sampling Locations

Well Location	**Geographical Location**	**Distance from Nearby River (m)**	**Well description**	**Nature of well**	**Water table depth (m)**	**Depth of well (m)**	Description of Sites
Oke Ijebu Akure	(7 º 15’ 46.6 N), (5º 12’ 14.6 E)	29	Coca-cola in Oke Ijebu	Covered with iron metal	4	23	Commercial Area traffic area
Iyeoma Plaza Akure	(7º 15’ 07.12 N), (5º 13’ 15.31 E)	2	Iyeoma plaza dug well	Covered with wood	3	16	FADAMA agricultural activity, heavy traffic
Araromi Quarters Akure	(7º 15’4.17 N), (5º 11’ 3.58 E)	11	Araromi quarters	Covered with wood	8	15	Sawmill, high traffic area

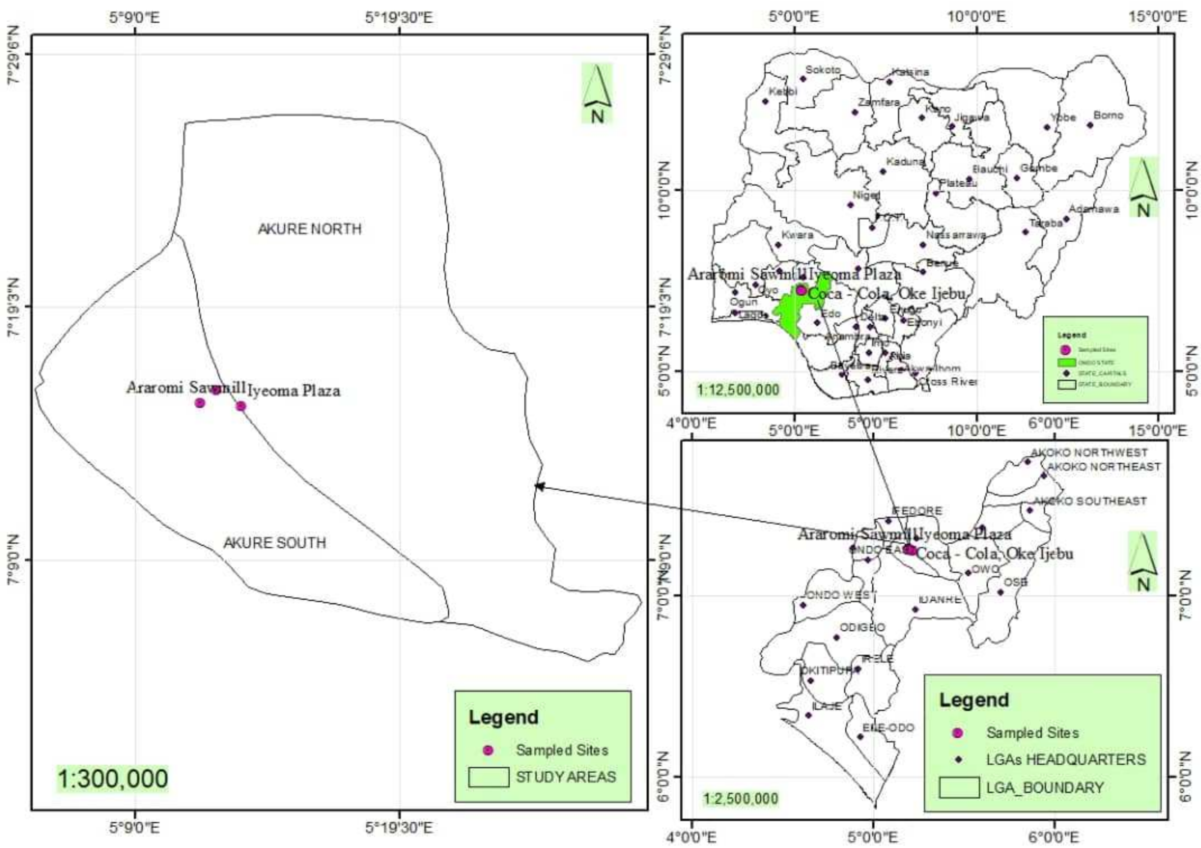


Figure 1: Akure study areas (Source: Field Work, 2018)

Samples were taken from dug well around Ala River namely Cocacola at Oke Ijebu, Iyeoma Plaza at Oba Ile Road, and Araromi Quarters (Figure 1). Dumpsites can be found in any area. The one in Araromi is a spot near a sawmill where wood dust and shavings are frequently burned. Near the Ala River is Oke Ijebu's. Many events, such as car washing and swimming, take place in this river. FADAMA agricultural activities are prevalent in the third site, Iyeoma plaza. A total of 36 water samples ranging from 15 to 150 mg bgl were obtained from wells located in Akure. The samples were filtered through membrane filters with a pore size of 0.45 microns and processed in polyethylene bottles that had been washed with nitric acid and thoroughly rinsed with distilled water. For cation measurements, another collection of samples was obtained and acidified to pH 2 with ultrapure nitric acid. The pH was measured with a pen-type pH meter (PH-009 (l)) made in China, while TDS, temperature, and EC were measured with a pen-type TDS and EC meter (EZ-1) made in China (Limgis, 2001).

To assess the suitability of the well-dug samples for drinking and irrigation purposes, the drinking water quality index and irrigation water quality index were determined. For the measurements, the World Health Organization's (2004) drinking guidelines were used.

Sodium adsorption ratio (SAR)

Since it is an indicator of alkali/sodium hazard to crops, SAR is an important parameter for assessing groundwater suitability for irrigation. The following formula is used to calculate SAR, where all ions' concentrations are measured in meq/l (Ayers and Westcot, 1994);

$$\mathrm{SAR} = \frac{Na^{+}}{\sqrt{\frac{\sqrt{Ca^{2+} + Mg^{2+}}}{2}}} \qquad 1$$

Soluble sodium percentage (SSP)

Todd (1980) suggested a soluble sodium percentage-based classification method for irrigation water (SSP). Using the formula below, the SSP was determined:

$$\mathrm{SSP} = \frac{Na^{+} \times 100}{Ca^{2+} + Mg^{2+} + Na^{+} + K^{+} +} \qquad 2$$

Ion concentrations are given in meq/l. SSP values less than 50 indicate good water quality, while SSP values greater than 50 indicate water that is unfit for irrigation (Todd, 1980). Table 4 shows that the majority of groundwater samples have SSP values above 50, indicating that they are unfit for irrigation.

Magnesium adsorption ratio (MAR)

The Magnesium Adsorption Ratio (MAR) was calculated using the following equation (Raghunath 1987):

$$\mathrm{MAR} = \frac{Mg^{2+} \times 100}{Ca^{2+} + Mg^{2+}} \qquad 3$$

Where all the ionic constituents are expressed in meq/l

Kelly’s ratio (KR) (Kelly, 1963)

$$KR = \frac{Na^{+}}{Ca^{2+} + Mg^{2+}} \qquad 4$$

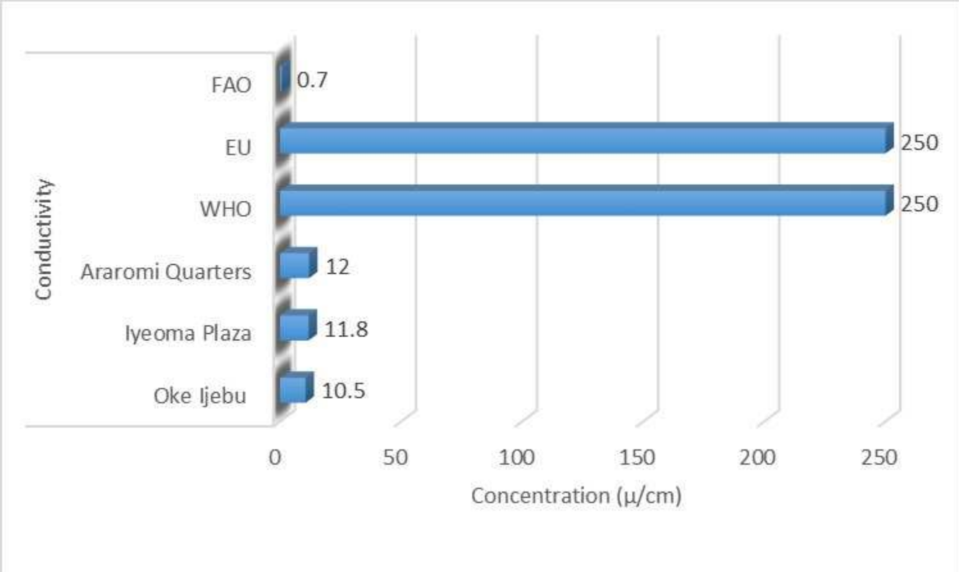
Exchangeable Sodium Percentage (ESP)
SAR is the SAR of the soil solution resulting from irrigation with groundwater, as predicted by USDA in 1954. According to USDA classification, the irrigation waters' salinity and sodicity hazards were calculated (USDA, 1954).

$$ESP = \frac{100x(-0.0126 + 0.01475\ SAR)}{1 + (-0.0126 + 0.01475\ SAR)} \qquad 5$$

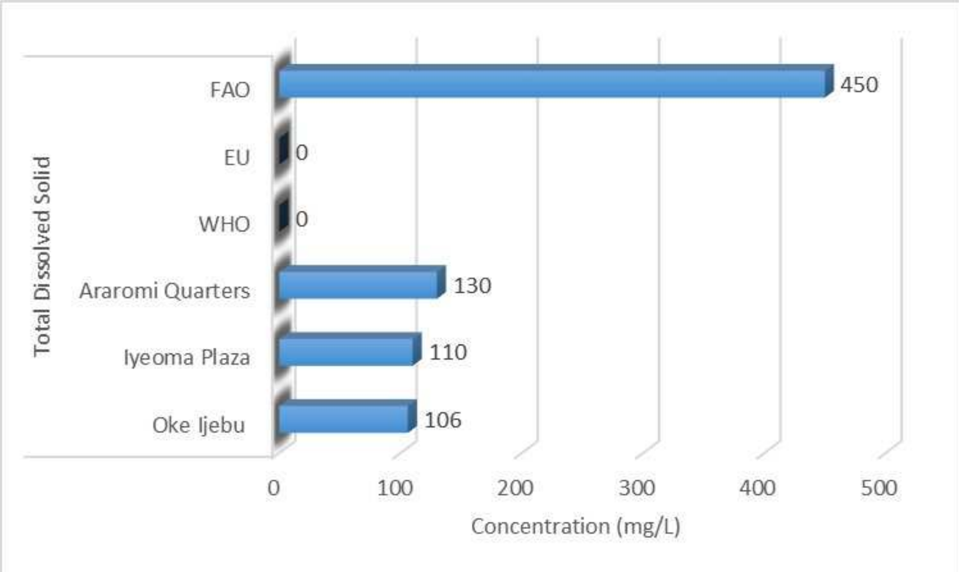
Minitab 16 Statistical Software was used to conduct statistical analysis on the data.

RESULTS AND DISCUSSION

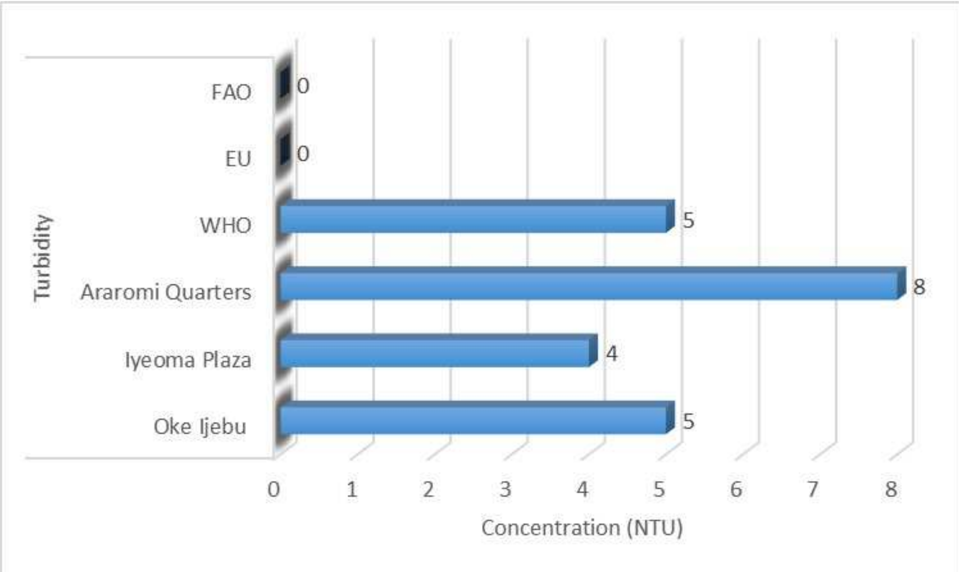
The results of the well dug water samples are shown in Figure 2 with their pH, DO, total hardness, turbidity, TDS, and conductivity. The water samples had a pH range of 6.4 to 7. The range of sampling points is shown in the graph. Water pH variations show that the pH was lower in Oke Ijebu and higher in Araromi. It's possible that the low pH was caused by a nearby dumpsite and a sawmill. Water with a pH less than 6.5 is more likely to be polluted, making it unsafe to drink. It can also corrode (dissolve) metal pipes. The pH levels of the water samples listed here are lower than FAO and WHO's recommended limits. The pH levels in the samples are also within the WHO (2011), European Community (EPA, 2010), and Normal Organization of Nigeria (2007) water limits of pH 6 and 9 (bathing water) and 6.5-9.5 (drinking water). The pH values were higher than those recorded by Bisht et al., (2015) in India (5.92), Zhou et al., (2015) in China (3.3), Park and Yang (2021) in South Korea (4.3-5), and Ojekunle et al., (2020) in Nigeria (4.35), which may be due to alkaline species dominance. The pH values in the study are within the ranges of 6.14–7.50 reported by Saana et al. (2016) and 6.35-8.31 (Popoola et al., 2019) for Ghanaian and Nigerian water, respectively, but less than 7.61-8.34 reported for Indian water (Annapoorna and Janardhana, 2015).



Conductivity
FAO
EU
WHO
Araromi Quarters
Iyeoma Plaza
Oke Ijebu
0.7
250
250
12
11.8
10.5
0
50
100
150
200
250
Concentration (µ/cm)



Total Dissolved Solid
FAO
EU
WHO
Araromi Quarters
Iyeoma Plaza
Oke Ijebu
450
0
0
130
110
106
0
100
200
300
400
500
Concentration (mg/L)



Turbidity
FAO
EU
WHO
Araromi Quarters
Iyeoma Plaza
Oke Ijebu
0
0
5
8
4
5
0
1
2
3
4
5
6
7
8
Concentration (NTU)

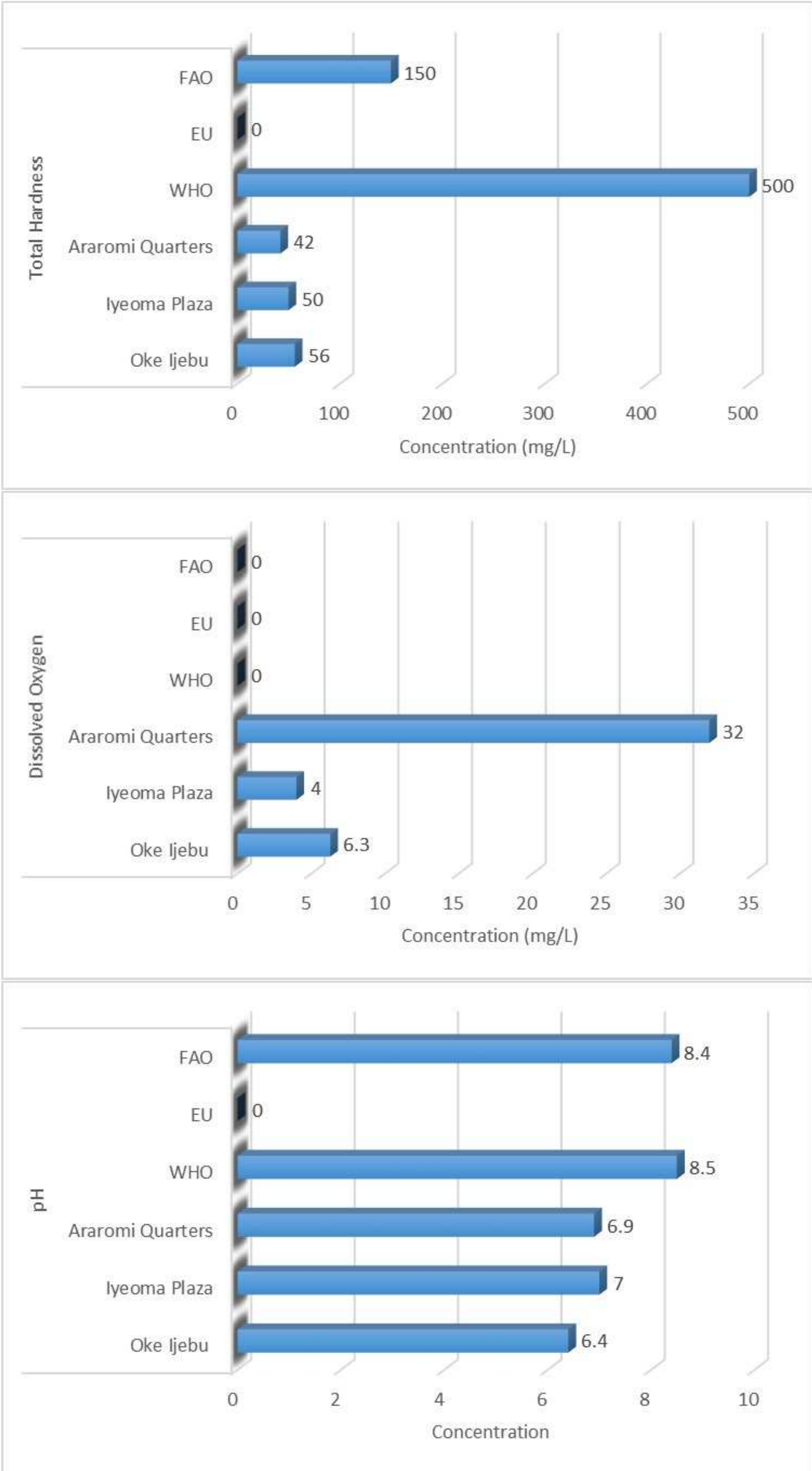


Figure 2: The Physico-Chemical Characteristics of the samples Compared with the Standards

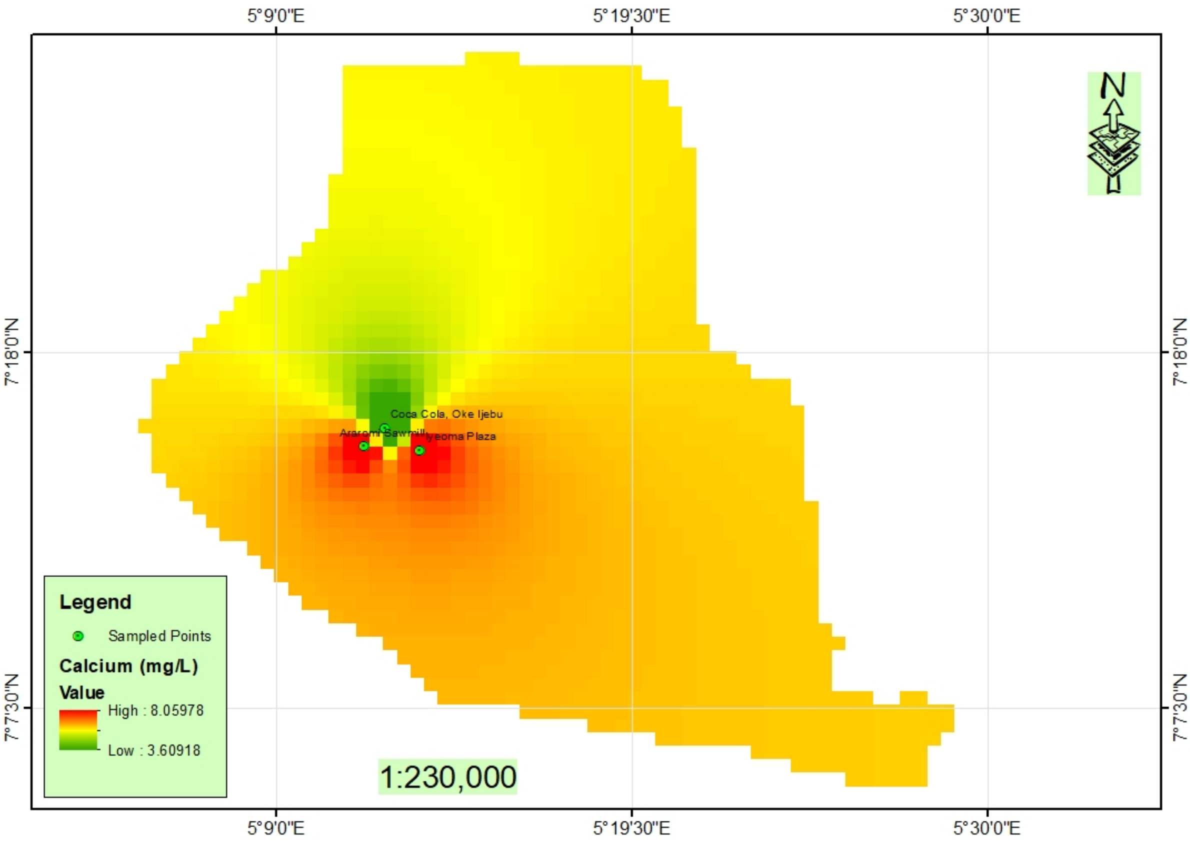
During the study period, the electrical conductivity (EC) in the water samples was between 10.5 and 12.0 S/cm, which was within the range reported by Bashit et al. (2015), significantly higher than the value (5.05 µS/cm) reported in the Himalayan region by Tiwari et al. (2012), but lower than that reported (12.1-81.9 µS/cm) by Park and Yang (2021a, b). Water sample EC values were higher than the observed value of 13.7 to 476 S/cm in a Pakistani megacity in Southeast Asia (Masood et al., 2018) and 45.3 µS/cm in Nigeria (Abulude et al. (2020). High EC values indicate that the study area's atmosphere is of poor quality (Masood et al., 2018). The higher soil-derived aerosols, which were entrained into the wells by windblown dust from an unpaved lane, may explain the conductivity values found in the study areas.

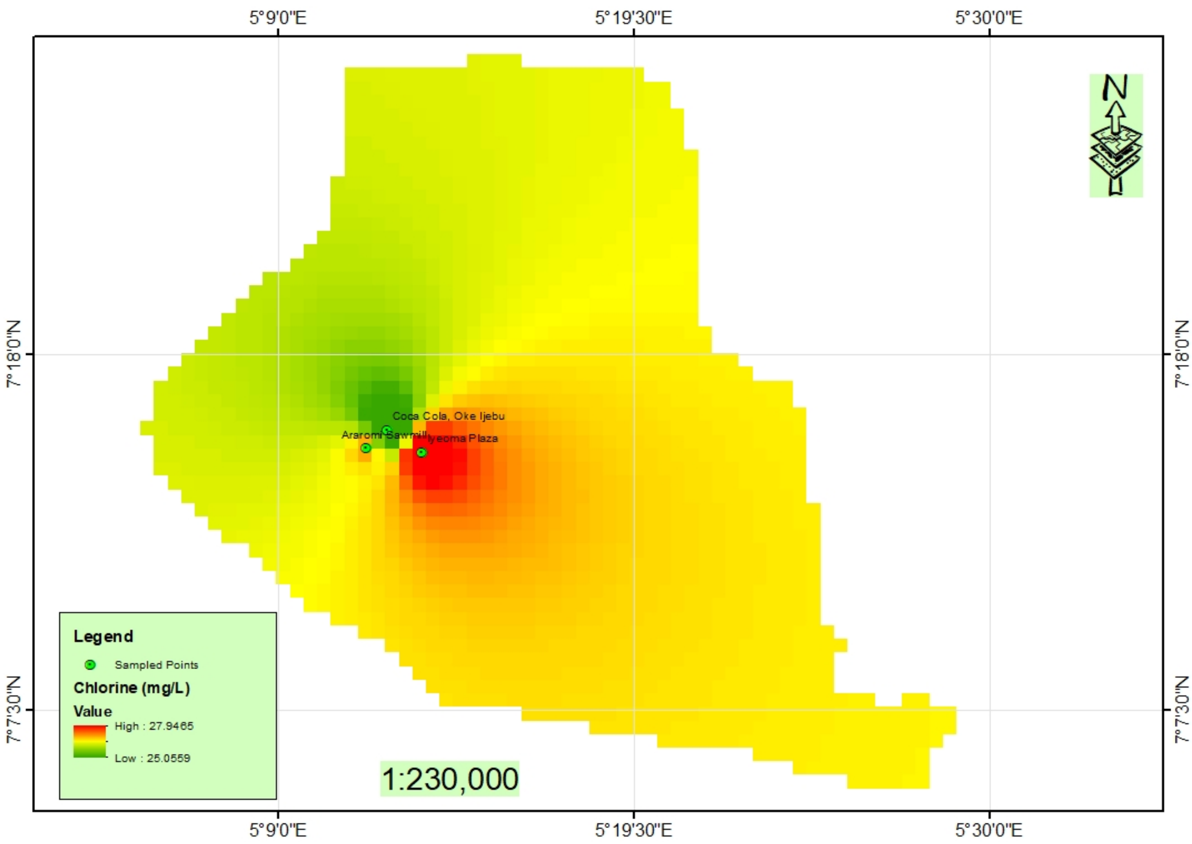
The mean TDS values ranged from 106.0 mg/l to 130 mg/L (Oke Ijebu>Iyeoma Plaza>Araromi Quarters). The TDS values were not comparable with mean values ranged from 43.5 to 46.3 mg/L in Uganda (Ngabirano et al., 2016) and 42.5 mg/L in Nigeria (Abulude et al., 2018). Higher temperatures during the dry season may have aided dissolution, ion exchange capability, desorption, and weathering processes. During the dry season, the water evaporated, resulting in higher ion concentrations (Ngabirano et al., 2016).

The turbidity values for Oke Ijebu, Iyeoma Plaza, and Araromi Quarters were 5.0 FTU, 4.0 FTU, and 8.0 FTU, respectively. Although the values were within the range of the maximum permissible limit of < 10 FTU, turbidity does not cause serious harm to crops (WHO, 2004). A high turbidity level allows silt to settle downstream in the water. If the water is used for irrigation, the suspended matter can clog soil pore spaces, causing poor drainage and increased runoff, which may result in flooding and erosion (Chukwu, 2005).

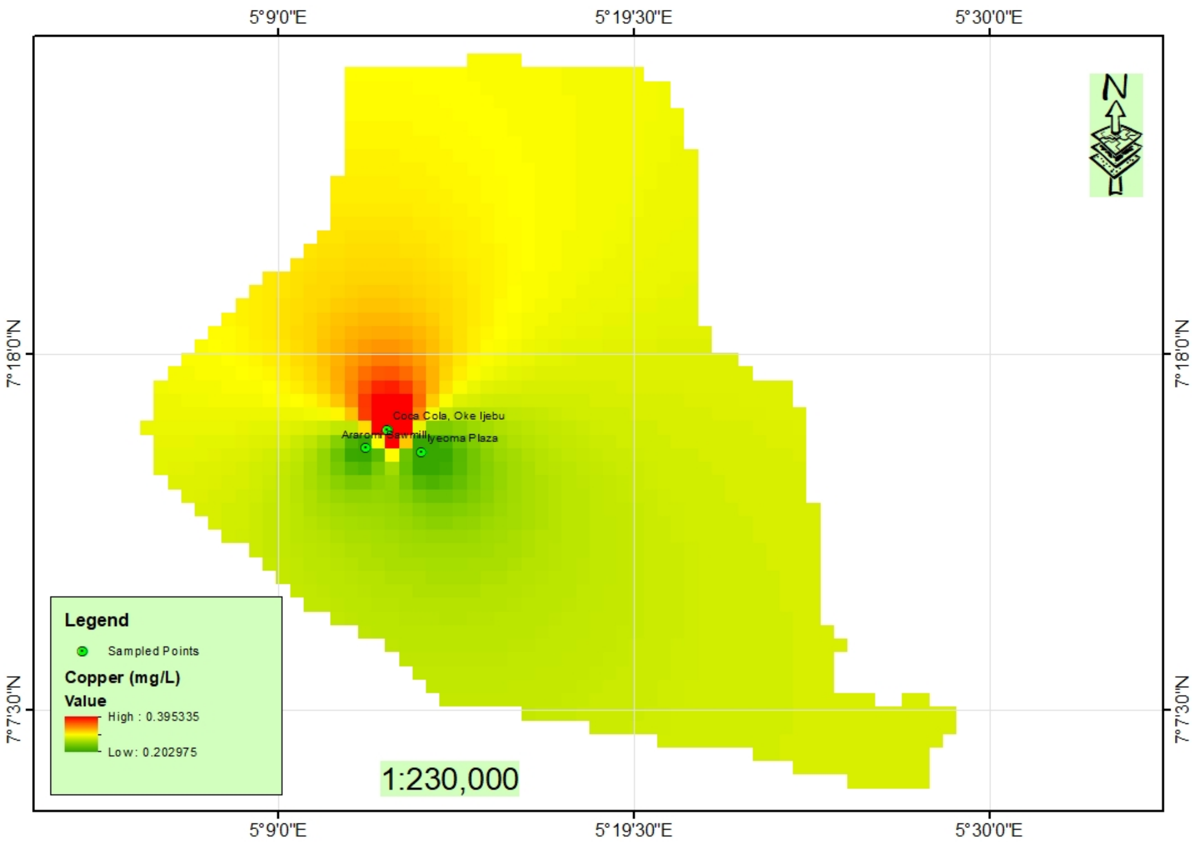
The Total Hardness of the water samples from Oke Ijebu, Iyeoma Plaza, and Araromi Quarters concentrations were in the ranges of 56mg/L, 50mg/L, and 42mg/L respectively. These water samples are soft this is possibly due to low concentrations of calcium, magnesium, chloride, and sulphate. The capacity of water to prevent the formation of ample lather with soap is a measure of its hardness. Water hardness is caused by the presence of bicarbonate, sulfate, chloride, and calcium and magnesium nutrients. To compensate for the deficiency, calcium fertilizer must be added to the water for irrigation purposes (Michael, 1999).

The Dissolved Oxygen levels in this study varied (DO). The DO in this study was similar to that (4.78 – 6.81 mg/L) stated by Bwire et al. (2020). The amount of DO in water is a good measure of water quality and a key factor in water purification. The dissolved oxygen concentration can represent the environment's self-regulating state; a high dissolved oxygen content means that the water can be filtered rapidly because it facilitates the oxidation of various contaminants in the water (Wei et al., 2019). A community water source with high dissolved oxygen (DO) level is beneficial because it improves the taste of the water. Low DOC in irrigation water, according to (Maestre-Valero and Martnez-Alvarez (2010), can have serious implications because it causes root oxygen deficiency, which can lead to agronomic issues; however, high DO levels accelerate corrosion in water pipes. As a result, factories use water that contains as little dissolved oxygen as possible. In a nutshell, the concentrations discovered in this study can explain why the water samples are safe to drink. A high level of DO is beneficial to root growth when used for irrigation. When there is less water in the water than there is in the root, the permeability of the roots to water decreases, and the absorption of nutrients decreases (or even reverses). Irrigation water that has been oxygenated has been shown to increase plant biomass in some studies (Yafuso and Fisher, 2017).

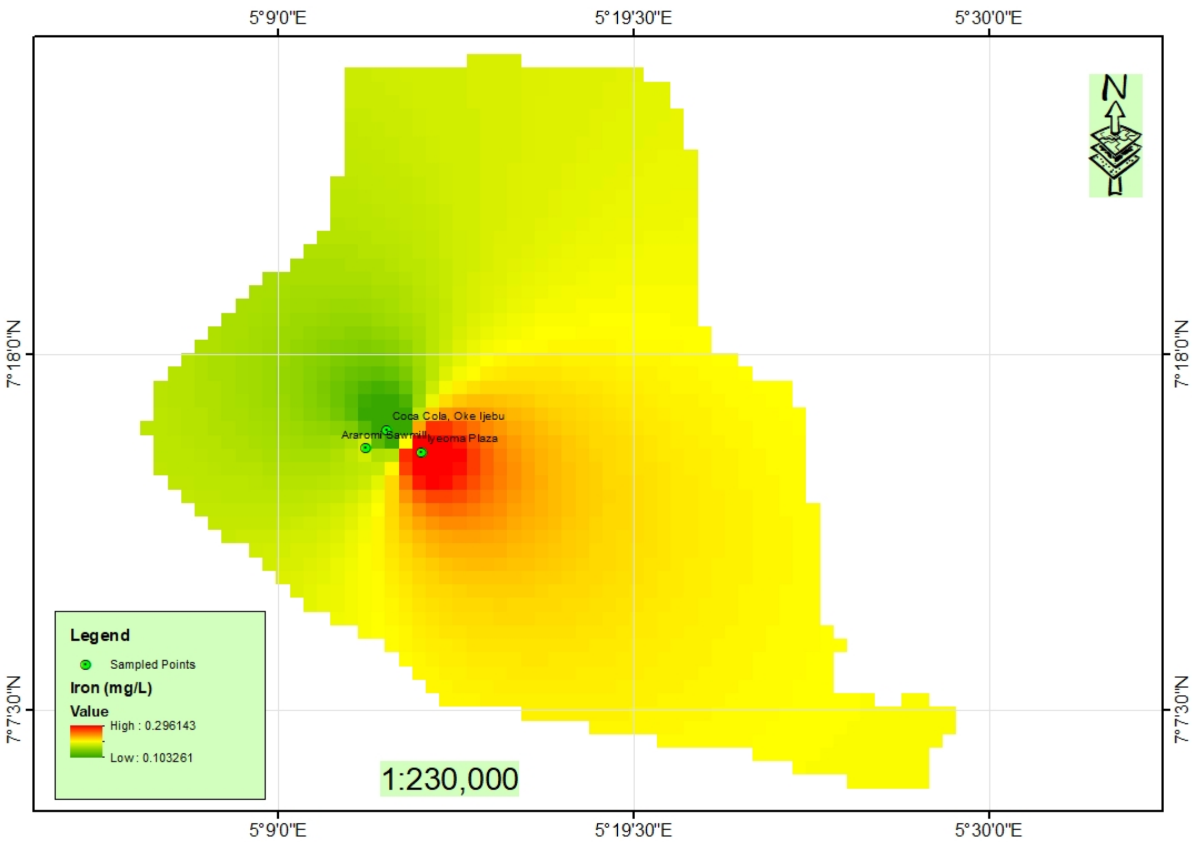




5°9'0"E
5°19'30"E
5°30'0"E
7°18'0"N
7°7'30"N
N
Coca Cola, Oke Ijebu
Araromi Sawmill
Iyeoma Plaza
Legend
Sampled Points
Chlorine (mg/L)
Value
High : 27.9465
Low : 25.0559
1:230,000



5°9'0"E
5°19'30"E
5°30'0"E
7°18'0"N
7°7'30"N
N
Coca Cola, Oke Ijebu
Araromi Sawmill
Iyeoma Plaza
Legend
Sampled Points
Copper (mg/L)
Value
High : 0.395335
Low : 0.202975
1:230,000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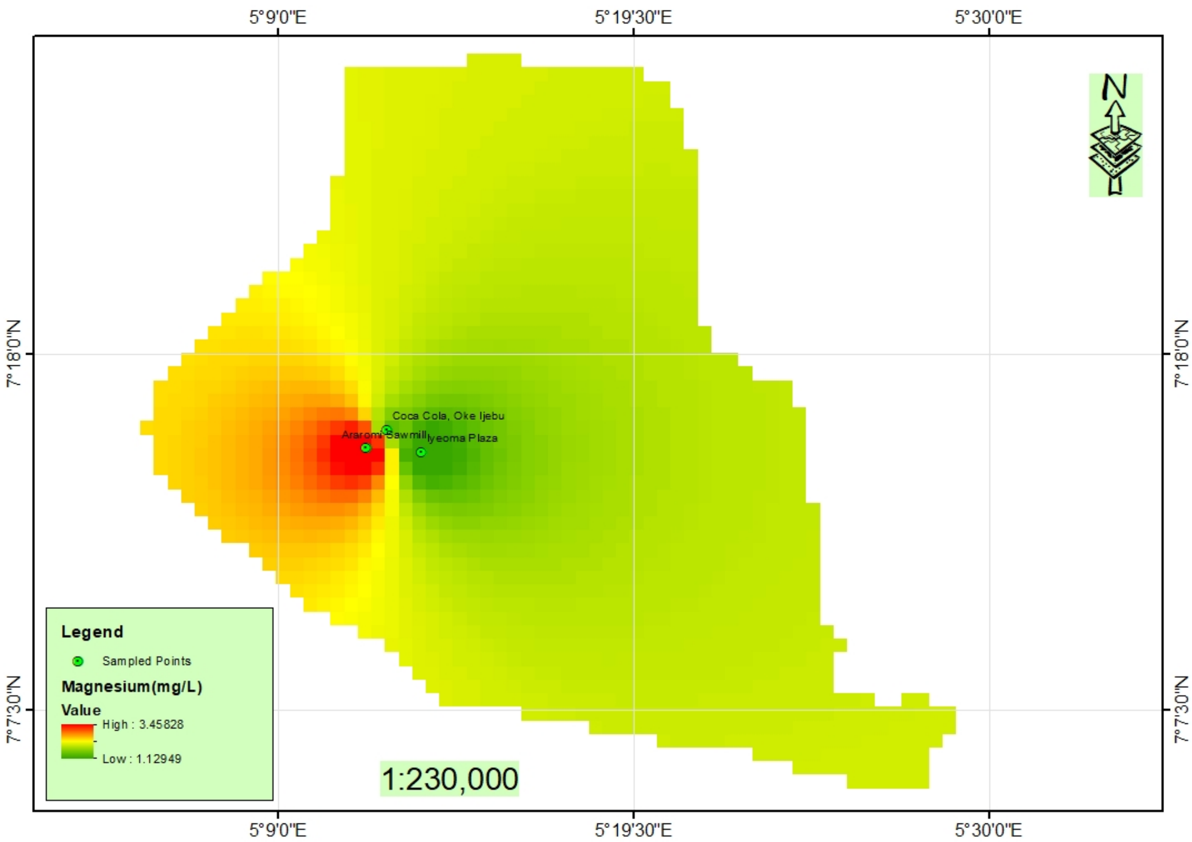
5°30'0"E
7°18'0"N
7°7'30"N
N
Coca Cola, Oke Ijebu
Araromi Sawmill
Iyeoma Plaza
Legend
Sampled Points
Iron (mg/L)
Value
High : 0.296143
Low : 0.103261
1:230,000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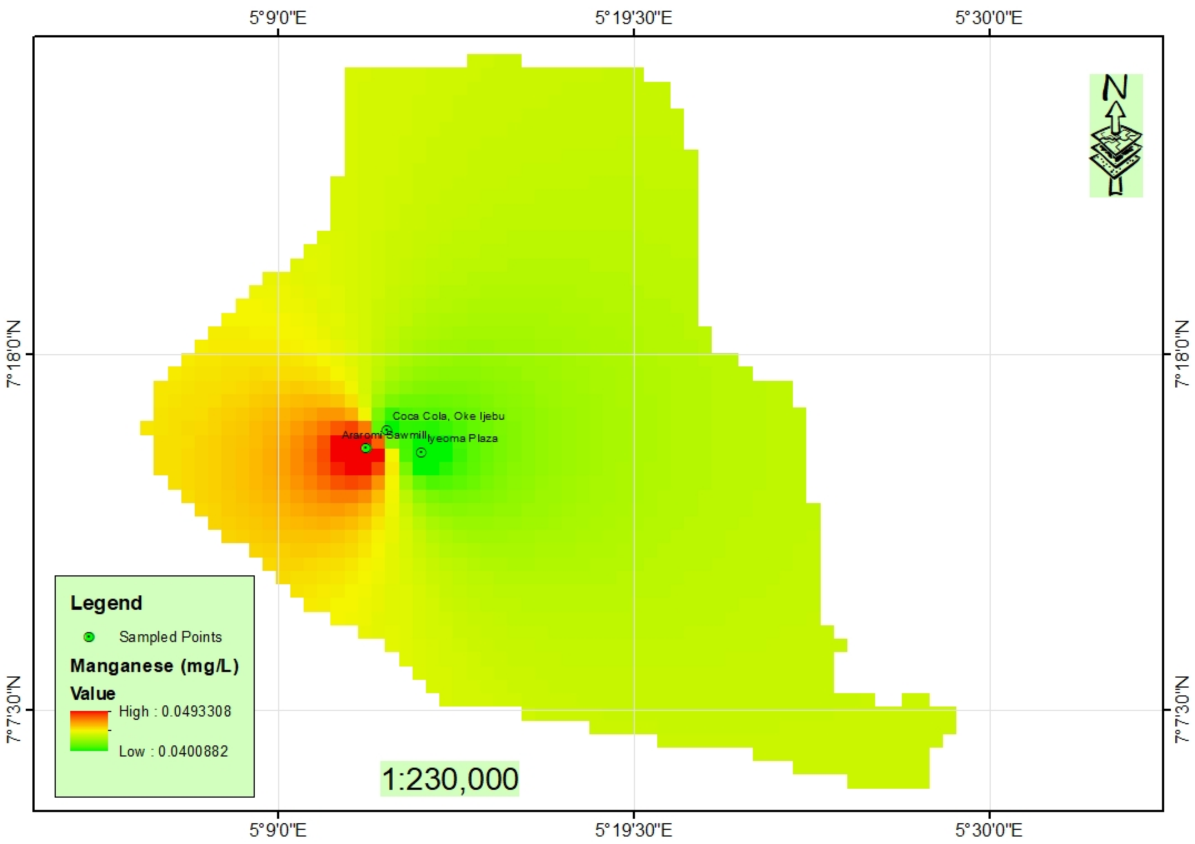
5°19'30"E
5°30'0"E
7°18'0"N
7°7'30"N
N
Coca Cola, Oke Ijebu
Araromi Sawmill
Iyeoma Plaza
Legend
Sampled Points
Magnesium(mg/L)
Value
High : 3.45828
Low : 1.12949
1:230,000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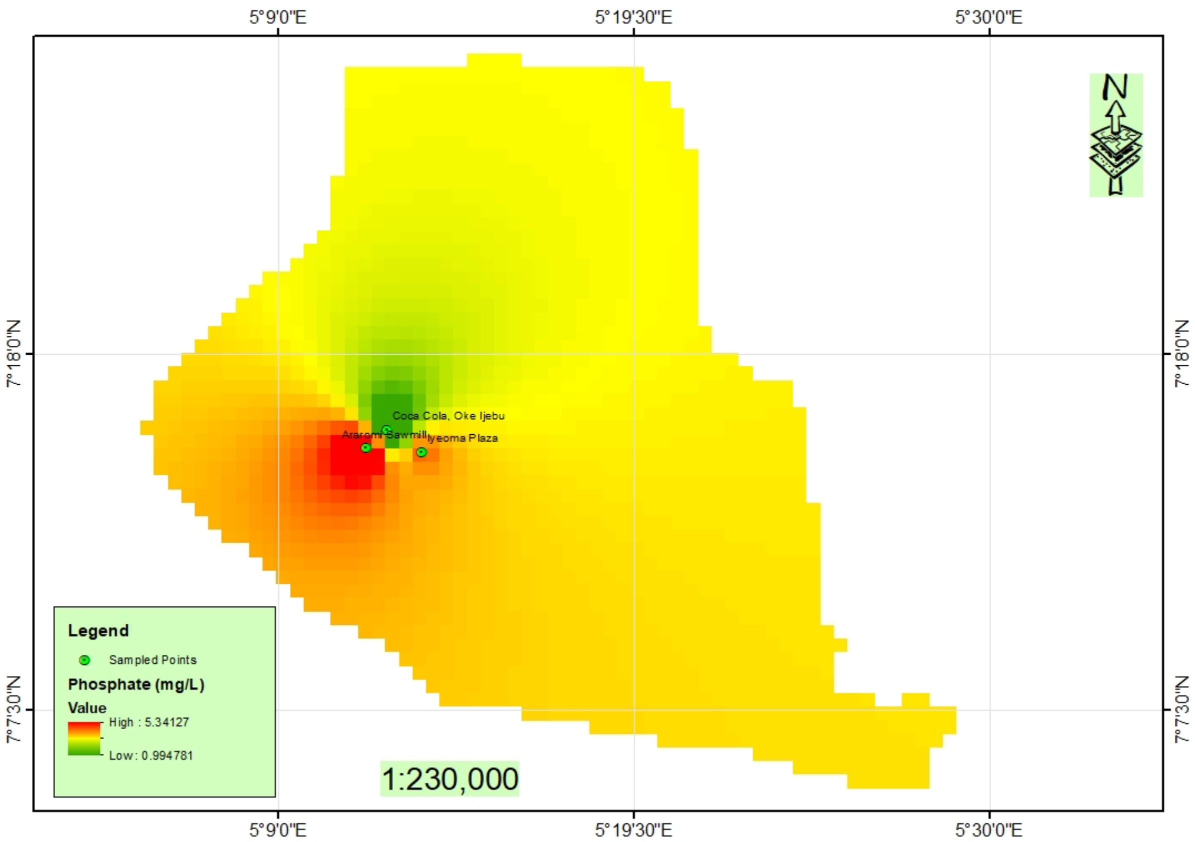
5°19'30"E
5°30'0"E
7°18'0"N
7°7'30"N
Coca Cola, Oke Ijebu
Araromi Sawmill
Iyeoma Plaza
Legend
Sampled Points
Manganese (mg/L)
Value
High : 0.0493308
Low : 0.0400882
1:230,000
N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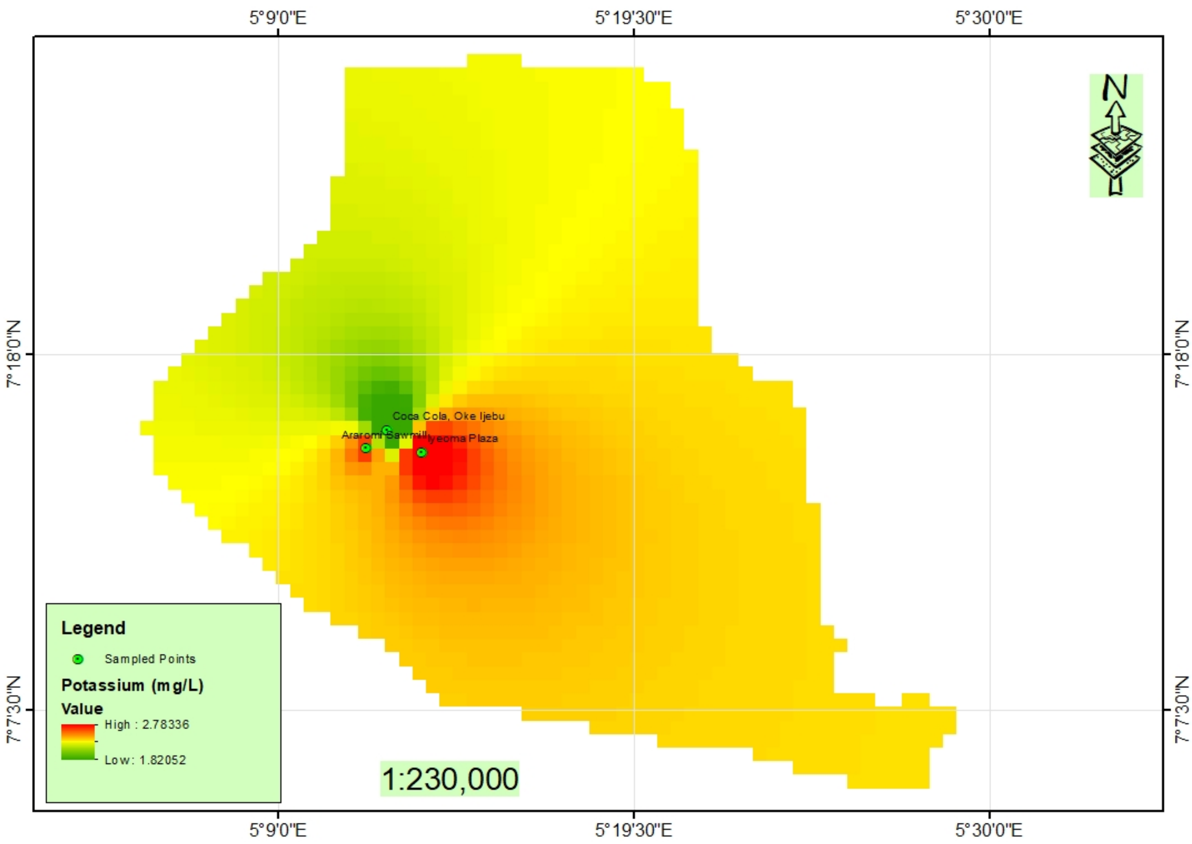
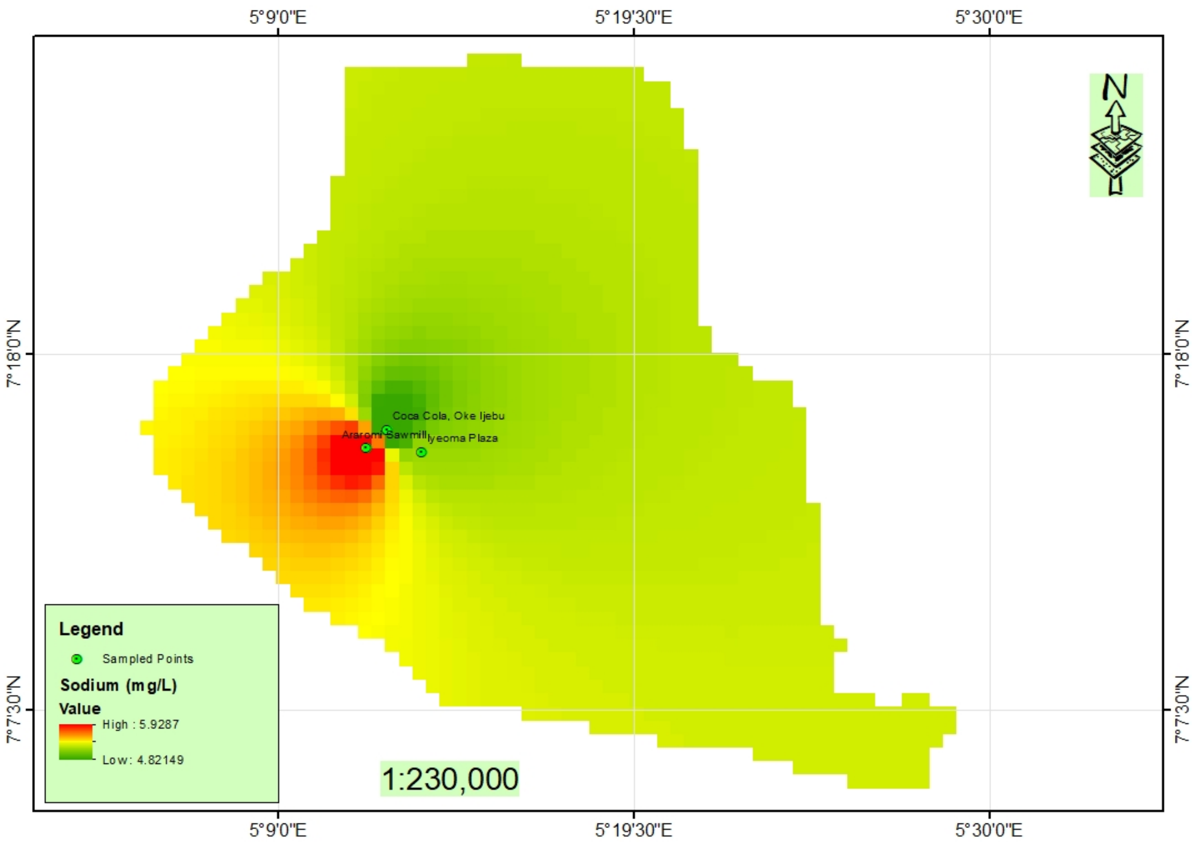
5°19'30"E
5°30'0"E
7°18'0"N
7°7'30"N
Coca Cola, Oke Ijebu
Araromi Sawmill
Iyeoma Plaza
Legend
Sampled Points
Phosphate (mg/L)
Value
High : 5.34127
Low : 0.994781
1:230,000
N


5°9'0"E
5°19'30"E
5°30'0"E
7°18'0"N
7°7'30"N
Coca Cola, Oke Ijebu
Araromi Sawmill
Iyeoma Plaza
N
Legend
Sampled Points
Potassium (mg/L)
Value
High : 2.78336
Low : 1.82052
1:230,000


5°9'0"E
5°19'30"E
5°30'0"E
7°18'0"N
7°7'30"N
Coca Cola, Oke Ijebu
Araromi Sawmill
Iyeoma Plaza
N
Legend
Sampled Points
Sodium (mg/L)
Value
High : 5.9287
Low : 4.82149
1:230,000

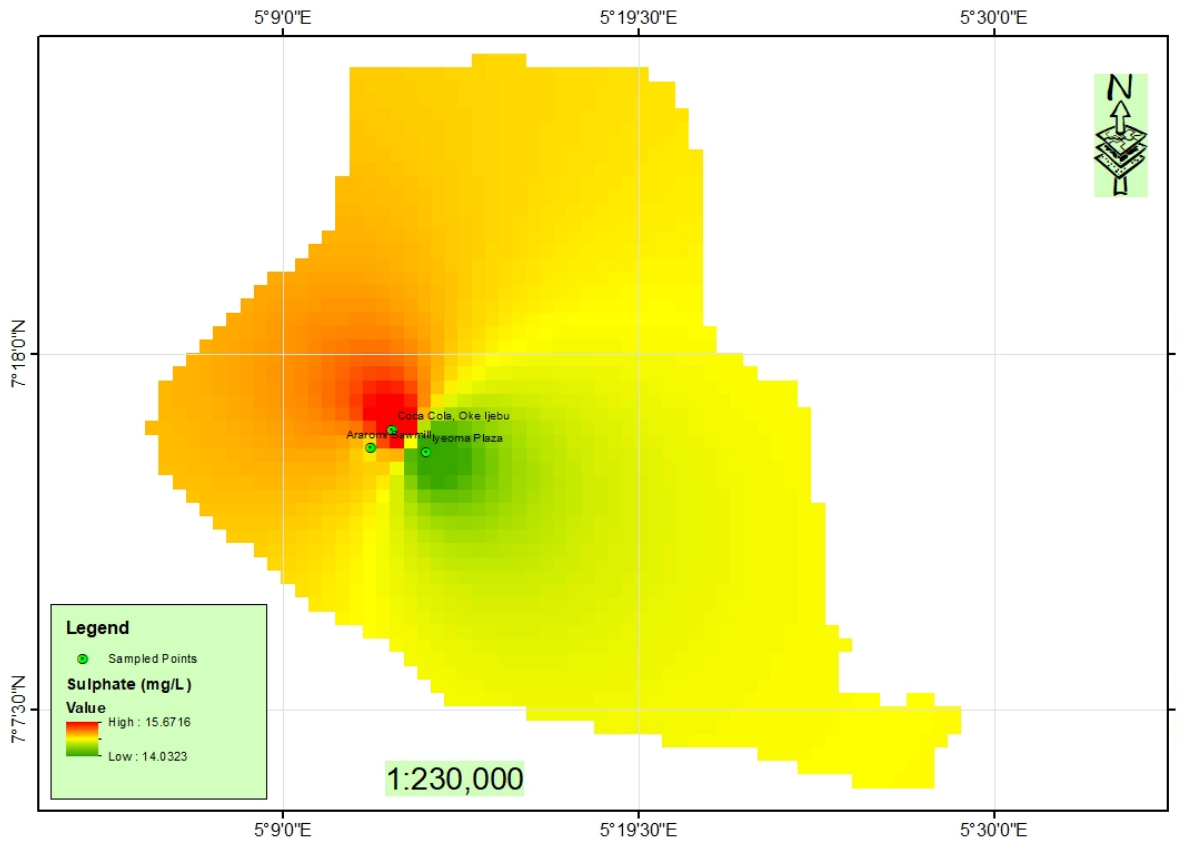
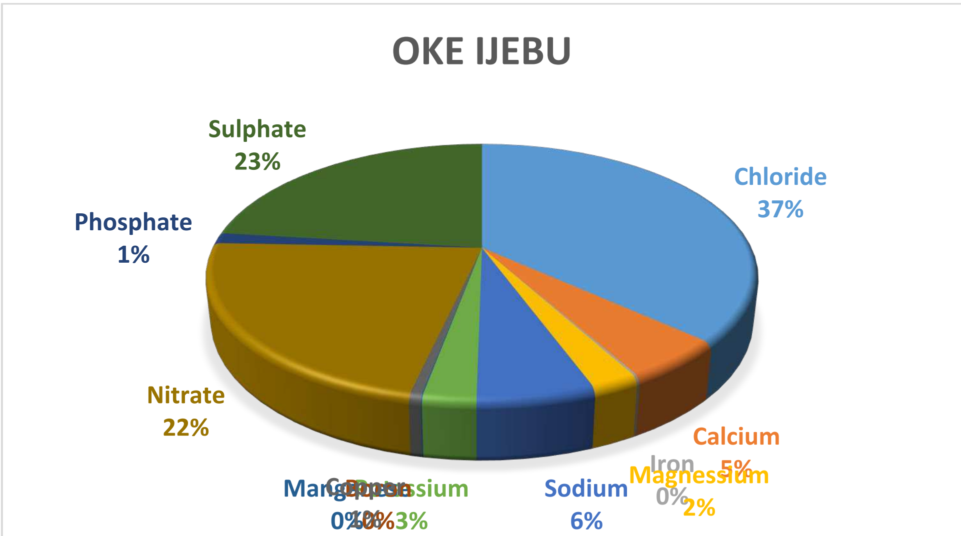


Figure 3: The ion compositions of the well dug water samples



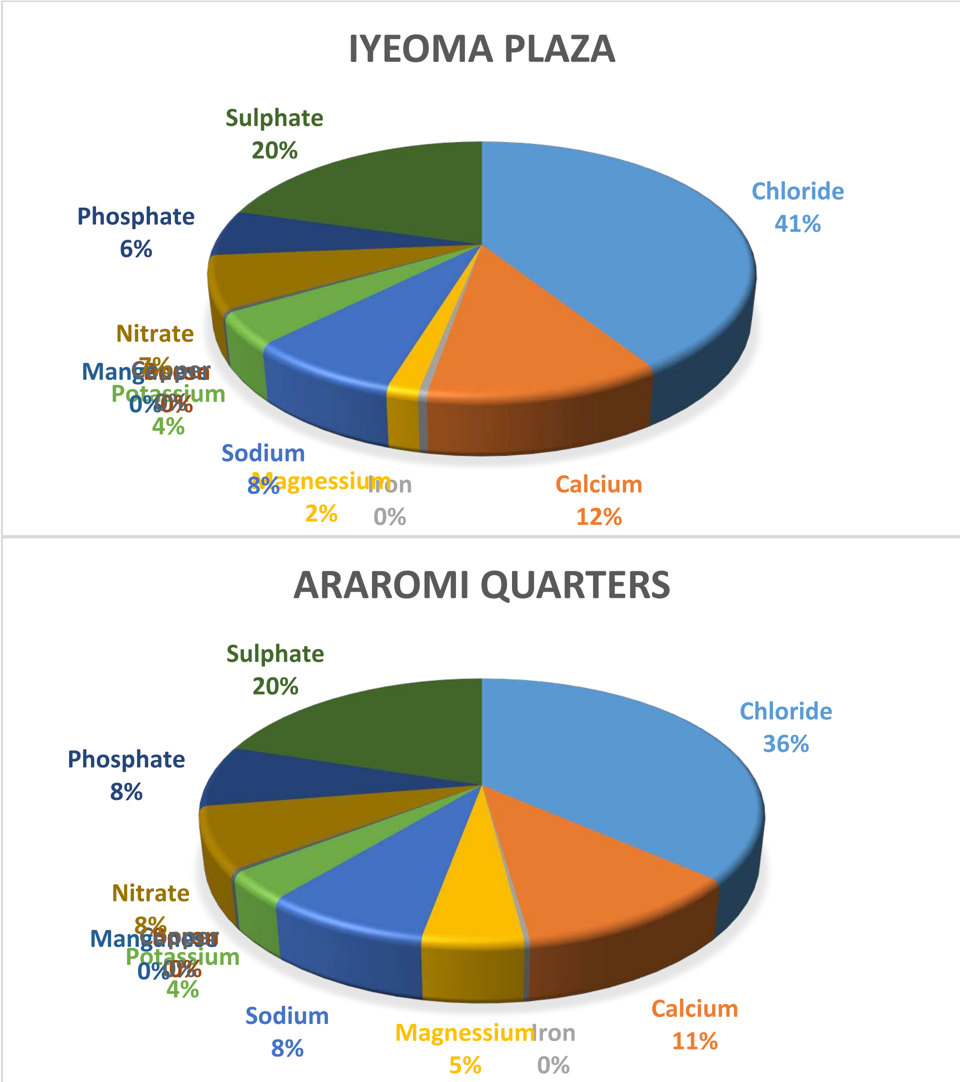


Fig. 4: Percentage contribution of total ionic composition in water samples

In well samples, the mean concentration (mg/L) of metal and non-metal species was in the order of: chloride > sulphate > nitrate > sodium > calcium > potassium > magnesium > copper > phosphate > iron > manganese, while category-wise abundance was in the order of: sodium > calcium > potassium > magnesium > copper > iron > manganese for cations and chloride > sulphate > nitrate > phosphate for anions (Fig. 3). Also, the percentage contribution of individual cations and anions in water saplings was calculated and shown in Fig. 4. It should be noted that sodium, calcium, and magnesium contributed approximately 6%, 5%, and 3% of the total cationic strength of samples in Oke Ijebu, respectively; similarly, in Iyeoma Plaza, calcium (12%), sodium (8%), and magnesium (2%), while in Araromi Quarters, the same cations were enriched with contributions of 11%, 5%, and 3%, respectively. In Oke Ijebu, Iyeoma Plaza, and Araromi Quarters, respectively, chloride made up about 37%, 41%, and 36% of total anionic strength. Overall, calcium contributed the most (11-12 percent) followed by chloride (36-41 percent) in Iyeoma Plaza and Araromi Quarters, while chloride (36-41 percent) makes a relatively small contribution in all water samples. The water samples were found to be enriched in sodium and chloride, which may be attributed to natural chloride spikes during the dry season "low flow" times when evaporation exceeds precipitation. Anthropogenic, or human-caused, causes such as road salt, waste runoff, and water softeners are believed to be responsible for rises in chloride concentrations at the sites. Another consideration may be the entrainment of atmospheric particulate matter in precipitation as it travels through the air masses' trajectories.

Minerals and gases interacting with water in its comparatively slow passage through the rocks and sediments of the Earth's crust, their movements through pores and crack openings in rocks, and the frequency of fetching since older waters present in the well may be highly mineralized, all affected the differences observed in the water samples from different places. While chlorides are usually harmless at low concentrations, well water containing high levels of sodium chloride can damage plants when used for gardening or irrigation, as well as impart an unpleasant taste to drinking water. It's encouraging to see how little the parameters determined in this study vary, implying that they're safe to drink and use for irrigation.

The sodium concentrations in the water samples from Oke Ijebu, Iyeoma Plaza, and Araromi Quarters ranged from 4.8 to 6.0 mg/L. (Fig. 3). Excess sodium in water can affect the permeability of the soil and have unfavorable effects on its properties (Houatmia et al., 2016). The three water samples had a 2:1 Mg: Ca ratio. Since at the same degree of salinity and SAR, adsorption of sodium by soils and clay materials is greater at higher Mg: Ca ratios, soil sodicity would increase. Magnesium has lower bounding energy than calcium, which helps it to absorb more sodium. Soil sodicity is defined as Mg: Ca ratio greater than 4. (Michael, 1999). Since the Mg: Ca ratio is less than 4, there are no restrictions on the use of dug well water for irrigation or drinking. For Oke Ijebu, Iyeoma Plaza, and Araromi Quarters, respectively, the potassium content is 1.8 mg/L, 2.8 mg/L, and 2.6 mg/L. The potassium levels were higher than those found in some water samples from Australia (Smith et al., 2014). The variations may be linked to the types of land management activities used near the water sample sites. The nitrate contents of Oke Ijebu, Iyeoma Plaza, and Araromi Quarters samples respectively, were 1.5 mg/L, 4.6 mg/L, and 6.2 mg/L. The nitrate levels are good for irrigation water. Nitrogen deficiency is normal in irrigated soil, but potassium levels are normally sufficient. Regular nitrate supplies can help to mitigate salt-induced nitrogen shortage and improve crop productivity (Michael, 1999).

Table 2: Some water quality accounts and water class

Parameters	Oke Ijebu	Iyeoma Plaza	Araromi Quarters	Water Class
SAR $(mEq/L)^{1/2}$	4.5	3.4	4.2	Excellent
ESP (%)	6.29	4.2	5.82	Excellent
SSP (mEq/L)	41.03	30	29.27	Excellent
MAR (mEq/L)	31.37	12.09	30.52	Excellent
KR (mEq/L)	0.94	0.58	0.5	Excellent
EC	10.5	11.8	12	No Problem
TDS	106	110	130	No Problem

SAR - Sodium Adsorption Ratio, ESP - Exchangeable Sodium Percentage, SSP - Soluble Sodium Percentage, MAR - Magnesium Adsorption Ratio, KR - Kelly's ratio, EC – Electrical Conductivity, TDS – Total Dissolved Solids

Table 3. Classes of irrigation water quality of EC, SAR, ESP, and RSC

Classes of Water	EC, dSm^{-1}	SAR $(mEq/L)^{1/2}$	ESP %
Excellent	> 0.25	10-Jan	<20
Good	0.25-0.75	18-Oct	20-40
Medium	0.75-2.00	18-25	40-60
Bad	2.00-3.00	>25	60-80
Very Bad	> 3.00		>80

Table 4. Guidelines for Kelly's ratio (KI) for irrigation water

I meq/l	Class
< 1	Safe
> 1	Unsuitable

Table 5. The sodium hazard of groundwater based on SAR values (Fipps, 1996)

Class	SAR	Remarks
Low	1 – 10	Use on sodium-sensitive crops such as avocados must be cautioned
Medium	10 – 18	Amendments and leaching needed
High	18 – 26	Generally unsuitable for continuous use
Very high	>26	Generally unsuitable for use

Table 6: Water Quality Classification Based on WQI Value

Water quality	No of samples (DWQI)	No of samples (IWQI)	Sustainable state
Excellent	All	All	Sustainable
Good	-	-	Sustainable
Poor	-	-	Slightly unstainable
Very Poor	-	-	Unstainable
Unfit for drinking/irrigation	-	-	Highly unsustainable

DWQI - drinking water quality index; IWQI - Irrigation water quality indices; WQI - Water Quality Index

Sodium Adsorption Ratio (SAR)

Since SAR values are less than indicate that the 10 samples in this study are excellent and good for irrigation, all of the samples in the study region were excellent and good for irrigation in this study (Table 2). SAR is used to classify water (Table 3). If the SAR value is less than 10, the water is excellent for irrigation, implying that all three samples of water supplies are excellent.

The Sodium-Adsorption-Ratio (SAR), also known as the adj.SAR or the adj.RNa ratio measures the proportion of sodium (Na^{+}) to calcium (Ca^{+2}) and magnesium (Mg^{+2}). The sodium hazards of irrigation water being soil solution after irrigation are assessed using these parameters. Sodium has a variety of impacts, including plant toxicity, poor soil drainage, and nutritional imbalance in plants. The mechanism is that irrigation water with a high sodium content raises the exchangeable sodium content of the soil exchange complex, causing the soil to spread more quickly. The soil macropores are sealed and permeability is decreased by the scattered soil particles. The supply of water to plants is greatly decreased under these conditions. Since SAR values are less than 10 indicate that all sample of the study area in Table (2) is excellent and good for irrigation. SAR is used to classify water (Table 3). If the SAR value is less than ten, the water is excellent for irrigation. All samples of water supplies from the Suez Canal Area fall into the excellent and good categories (Mohammed, 2017).

Exchangeable Sodium Percentage (ESP)

USDA, 1954, predicted the ESP, where SAR is the SAR of the soil solution resulting from groundwater irrigation. The irrigation waters' salinity and sodicity hazards were calculated using USDA classifications (1954). When a high concentration of sodium water is used, the value of exchangeable sodium is expected. Since the ESP values are less than 20. Classification of water with ESP is provided in this report, all samples of the study region are excellent and ideal for irrigation (Table 3). If the ESP value is less than 20, the water is excellent for irrigation, indicating that all samples of water supplies from the Suez Canal Region are excellent or fine.

Kelly’s ratio (KR)

Water was graded for irrigation using Kelly's ratio (Kelly, 1963). A Kelly's ratio greater than 1 implies that there is an excess of sodium in the water, hence, water samples with Kelly's ratio less than 1 were ideal for irrigation. Based on Kelly's ratio, all samples examined in this source are appropriate for use, according to the data in Tables 2 and 4. The results obtained for the ratio in this study are in agreement with the majority of the groundwater samples determined in Southern India (Anbazhagan and Jothibasum 2014).

Table 5 depicted the classification of water resources in the three locations based on water quality, with the results revealing that all water resources are classified as class 1. This research was compared to Mohamed's (2017) findings for four irrigation water sources in Egypt. Low pH, total dissolved solids, total hardness, calcium, magnesium, nitrate, chloride, and sulphate in well samples were found to be the key cause of the low DWQI value at these sites. In Oke Ijebu, Iyeoma Plaza, and Araromi Quarters, all water samples are of exceptional quality (Table 6). There were no good or bad drinking water quality index distributions reported. The DWQI and IWQI of the current study's overall Water Quality Index were outstanding. The groundwater quality for irrigation was assessed using a variety of irrigation water quality indices such as SAR, SSP, MAR, and KR. The values of the indices were applied together, and the water was categorized as outstanding (Tables 2 and 3).

CONCLUSION

This study aimed to determine whether three hand-dug wells in Akure, Ondo State, Nigeria, were suitable for drinking and irrigation. The determined physicochemical parameters were compared to standard limits. They are within the guidelines, according to the findings. Different indexes were used to assess the water quality for drinking (DWQI) and irrigation (IWQI) (ESP, SSP, SAR, MAR, KR, TDS, and EC). All of the samples were found to be outstanding. This proved their suitability for the two tasks.

Data Availability

On fair request, the corresponding author will provide the datasets produced and/or analyzed during the current research.

Declarations

Conflict of Interest

The authors declare that they have no conflict of interest to disclose.

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Author's Contributions

The study's conception and design were facilitated by all of the contributors. The investigators were in charge of material planning, data collection, and analysis. Francis Olawale Abulude wrote the first draft of the manuscript, which was reviewed by all of the contributors. The final manuscript was read and accepted by all contributors.

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Figures

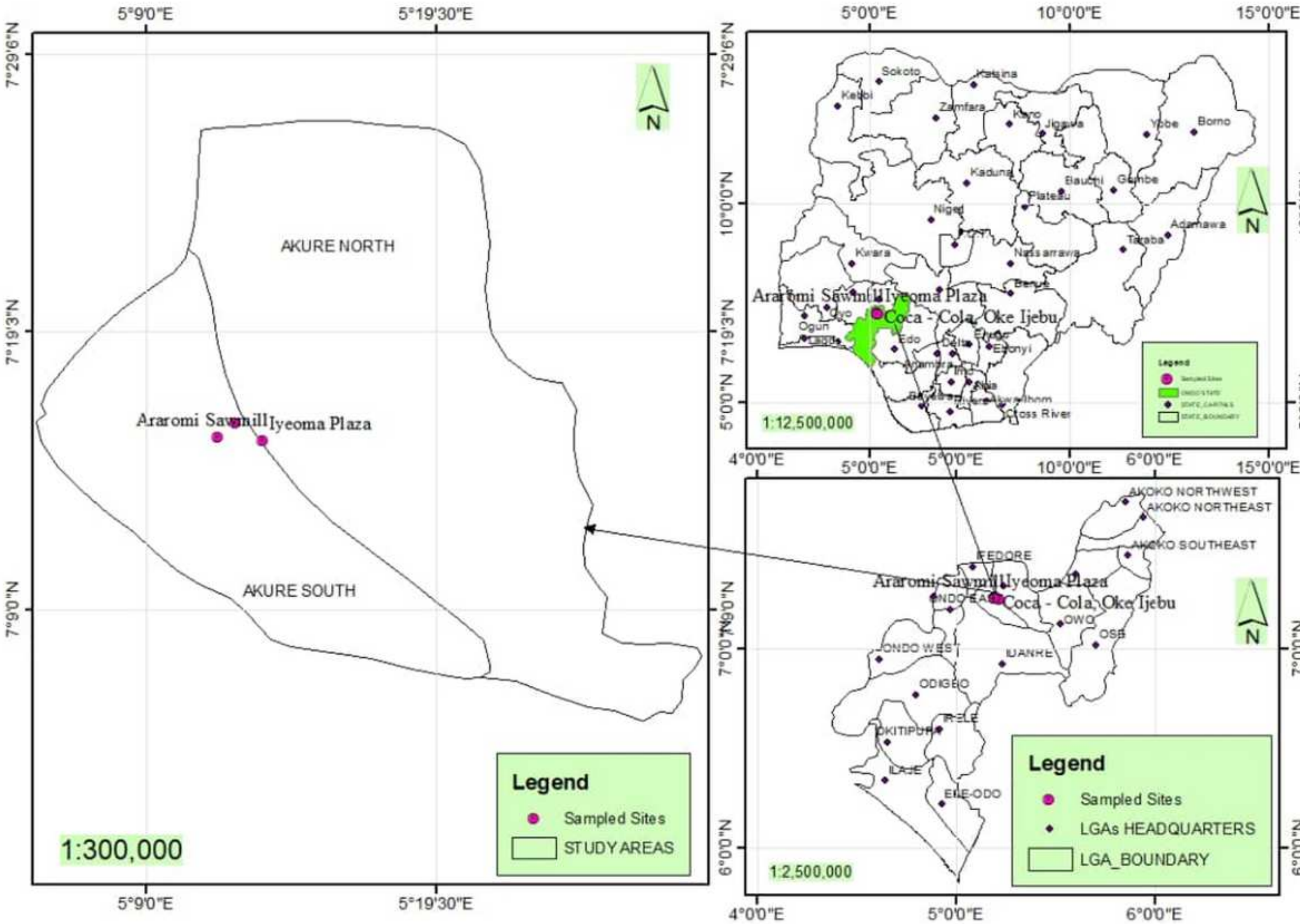

Figure 1

Akure study areas (Source: Field Work, 2018)

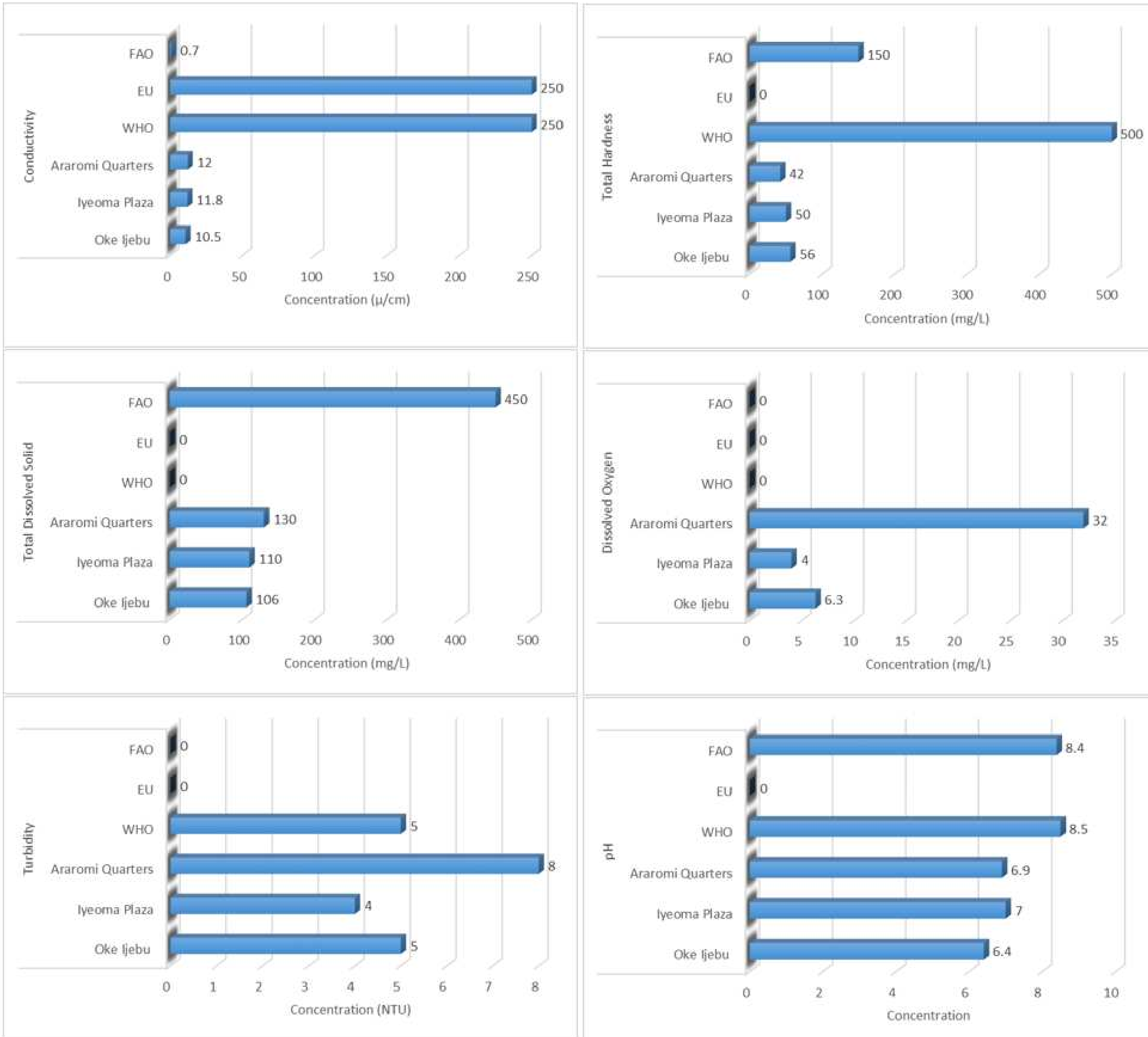

Figure 2

The Physico-Chemical Characteristics of the samples Compared with the Standards

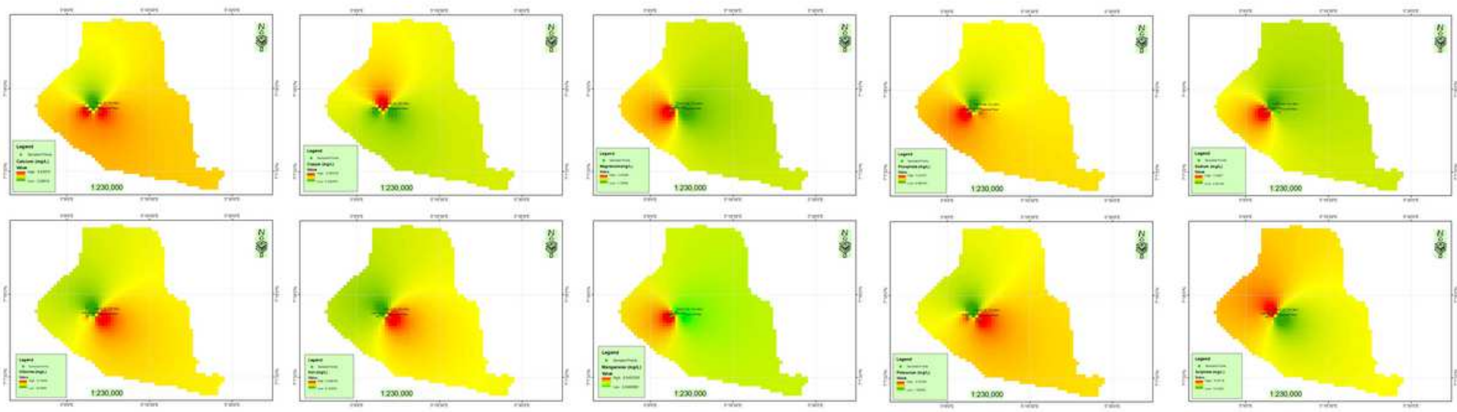

Figure 3

The ion compositions of the well dug water samples

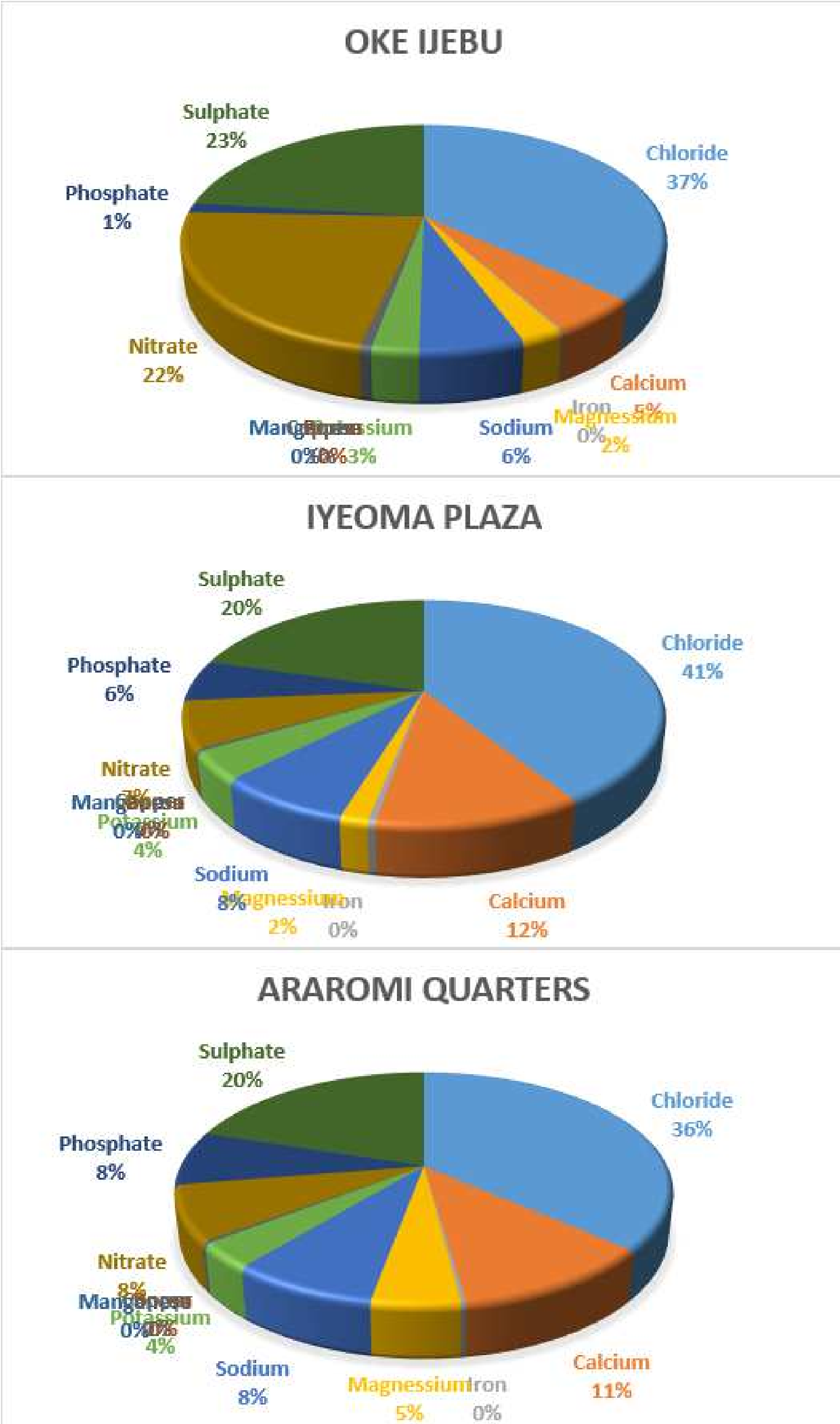

Figure 4

Percentage contribution of total ionic composition in water samples