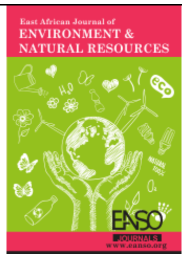

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Original Article

Assessment of Heavy Metals in Flowing Water at Ogun State, Southwestern Nigeria Using Water Quality Index Approach

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ABSTRACT

Human health and socioeconomic development depend on access to clean water. The ecosystem is threatened and the environment is harmed by water bodies in horrible conditions. Health problems affect the ecosystem (animals, people, and crop productivity) due to the increasing rate of water shortages brought on by inadequate management and a lack of government enforcement. This inspired the study to determine the quality of water used, including drinking for a healthy lifestyle. The Ijebu-North Local Government Area of Ogun State in Nigeria was the area of interest for the study test on the quality of the running water. Water samples were taken from ten different flowing water sources and examined with an ultraviolet-visible spectrometer. The analysis of the water quality parameters was compared with industry standards set by the World Health Organization and the National Agency for Food and Drug Administration and Control. The quality of residential water supply was also assessed using a weighted arithmetic water quality index approach. The weighted arithmetic water quality index findings indicated that the water in the study area was not safe for consumption due to its high turbidity. This study found that water in Ijebu North is unsuitable for drinking due to high turbidity and contaminants like iron. Industrial waste and poor waste management are major contributors to contamination, posing serious health risks. Stronger regulations, water treatment, and monitoring programs are needed to protect water quality and public health.

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INTRODUCTION

Water is one of the most crucial components of the cosmos, essential for sustaining life and maintaining the balance of nature. It is a chemical compound with the formula H_2O, held together by covalent bonds, and serves as the medium for all biological processes. Water covers 71% of the Earth's surface and is indispensable for all life forms (Talabi et al., 2020). However, water bodies are increasingly contaminated by sewage and various human activities, altering their hydro-chemical characteristics and microbiological purity. According to Dedeke and Omotosho (2008), leachate from random waste disposal is a significant source of pollutants in flowing water. Contaminated water continues to pose a severe threat to public health and quality of life, making it one of the most critical global health risks. In many cities in developing nations, clean water scarcity remains a persistent issue due to inadequate management and lack of government enforcement, threatening both human survival and ecosystem sustainability. Water quality is measured in terms of physical, chemical, and microbiological properties (Maimuna and Abdulrahman, 2012; Olbasa, 2017). It is an essential part of the ecosystem, providing various services (Zhou et al., 2012). Despite being one of humanity's most significant resources, access to safe drinking water and sanitation is challenging for billions of people in developing countries (Antonio 2005). This issue is critical for health in developed and impoverished nations (Olbasa, 2017).

Flowing water sources like rivers and streams are vital for freshwater supply but are vulnerable to pollution from unwanted materials, which degrade water quality and pose environmental and health risks (Haque et al., 2019; Alruman et al., 2016; Briggs, 2003), as an all-purpose solvent, water can be a major source of infection. According to Paweri and Gawande (2015), poor and filthy water conditions account for 3.1% of deaths globally, largely due to non-compliance with WHO guidelines (Khan et al. 2013). Freshwater availability and quality are declining, especially in developing countries where high-quality water is scarce. The United Nations World Water Assessment Programme (2006) reports that more than two million children die each year in these regions due to a lack of access to portable water, and one-third of the global population lives in areas with limited freshwater resources. Water scarcity is projected to worsen, potentially affecting agricultural labour demand and reducing options for labour-intensive crops (Booker and Scott, 2020; Duneal et al., 2020). In the Ijebu-North Local Government Area of Ogun State, South-western, Nigeria, the population has proliferated due to community educational advancements. This study

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was inspired by the need to assess the water quality in this area, which spans 967 km² and had a population of 284,336 as of the 2006 census. The current population has nearly tripled, driven by the presence of numerous educational institutions.

This study aimed to determine hydro-chemical concentration and the impact of anthropogenic activities on flowing waters in Ijebu North Local Government. By comparing the findings with standards set by authorities such as the WHO (2017), this research seeks to inform the public and environmental agencies about the state of the local water system. Additionally, it aimed to prompt government action to support youth in higher education to become more involved in water security and research, ultimately contributing to a higher standard of living.

MATERIALS AND METHODS

Ijebu North, established in 1979, is located in Ogun State, Nigeria, with its administrative headquarters in Ijebu Igbo. Geographically, it is positioned at a latitude of 6°58'0" N and a longitude of 4°0'00" E. The area is bordered by Oluyole Local Government of Oyo State to the North, Ijebu North East, Odogbolu, and Ijebu Ode Local Governments to the South, Ikenne Local Government to the east, and Ijebu East Local Government to the west. The climate in Ijebu North is tropical, characterized by alternating rainy and dry seasons. The region experiences significant rainfall, with the wettest months being June and September, and the driest period occurring from November to early March (Oloruntola and Adeyemi 2014). Temperatures in the area range between 21°C and 32°C throughout the year, fostering a rainforest vegetation typical of such a climate. Geologically, Ijebu North is part of the South Western Nigeria basement complex. The study area is composed of the migmatite gneiss complex and older granites with distinct structural dispositions (Rahaman 1976). These geological formations result in low porosity and permeability, making the basement complex a poor natural aquifer. Previous studies have highlighted environmental concerns in the area. For instance, Ariyo (2007) investigated the chemical characteristics of a dumpsite and its impact on boreholes in parts of Ijebu-Igbo. Their findings indicated low levels of total dissolved solids, nitrate, and chloride in the water, suggesting potential contamination issues that could affect water quality.

In this study, Water samples were collected directly from ten distinct locations within the study area (see Table 1) following procedures of Smith and Doe, (2021). Clean, white polyethene stoppered bottles, pre-washed with soap solution, rinsed with high-purity water, and treated with 1% HNO3, were used for sample collection. Before collecting the samples, the bottles were rinsed with the sample water to be collected. The collected water samples were then labelled appropriately. The samples were filtered using a 0.45 mm Millipore membrane filter and subsequently transferred to the laboratory, having been rinsed again with high-purity water and 1% HNO_3.

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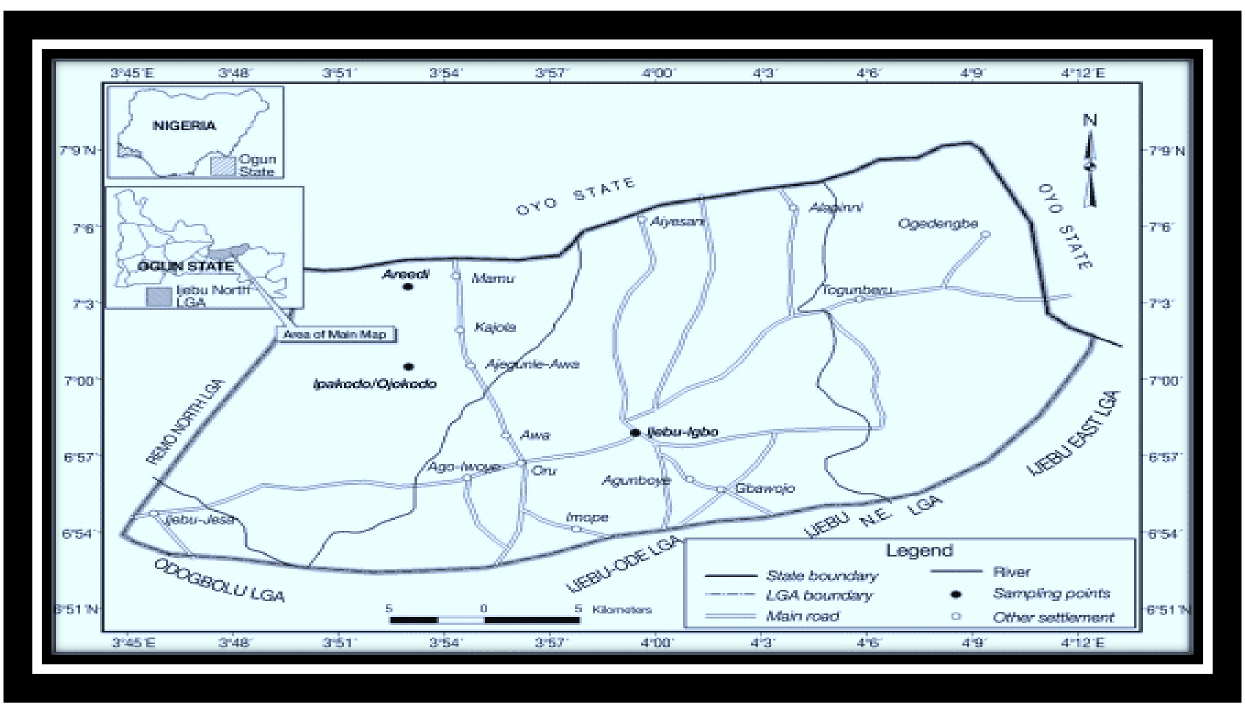
Table 1: Showing the Location of Samples

Locations	Code	GPS Coordinates Northing	GPS Coordinates Easting	Source
OOU Permanent site bridge (Ago-Iwoye)	A	$06^{0}56.15$”	$03^{0}55.65$”	Flowing water
Konigba (Ago-Iwoye)	B	$06^{0}56.78$”	$03^{0}53.94$”	Flowing water
Back of Mini Campus OOU (Ago-Iwoye)	C	$06^{0}57.50$”	$03^{0}54.23$”	Flowing water
Fidigbade (Ago-Iwoye)	D	$06^{0}56.68$”	$03^{0}54.47$”	Flowing water
Egbe (Ijebu-Igbo)	E	$06^{0}58.35$”	$04^{0}00.71$”	Flowing water
Odo lapata (Ijebu-lgbo)	F	$06^{0}52.48$”	$04^{0}00.20$”	Flowing water
Odobotu (Ijebu-Igbo)	G	$06^{0}57.99$”	$04^{0}00.27$”	Flowing water
Fumodara (Ijebu-Igbo)	H	$06^{0}58.18$”	$03^{0}59.41$”	Flowing water
Liberty Road (Oru)	I	$06^{0}57.19$”	$03^{0}57.12$”	Flowing water
Obanta (Oru)	J	$06^{0}57.85$”	$03^{0}55.82$”	Flowing water

Figure 1: Location Map of Ijebu North Local Government Area in Ogun State



Source: Hassan et al. (2011)

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At each sampling location, hydro-geophysical characteristics such as water level and overall depth of the wells were recorded. Water samples were physically evaluated for temperature, odour, colour, and taste using a thermometer and a turbidimeter.

For the chemical analysis, the following chemicals and reagents were used: methyl red, hydrogen chloride, ammonium chloride, ethylenediaminetetraacetic acid (EDTA), eriochrome black T indicator, buffer solution, sodium chloride, silver nitrate, potassium dichromate indicator, fluoride tablets 1 and 2, alkaline iodine, sulphuric acid, and sodium periodate. Water samples were analyzed for the presence of heavy metals and chemical properties, including pH, total hardness, total solids, alkalinity, total dissolved solids, and electrical conductivity. A Hach 2000 pH meter was used to measure the pH levels of the samples, while a CIBA-CORING conductivity meter determined the electrical conductivity and total dissolved solids (TDS). Turbidity was measured using a turbidimeter.

Methods

To measure pH, the pH meter was calibrated using buffer solutions at pH 4, 7, and 10, following the method by Dan'azumi and Bichi (2010). The electrode was rinsed with distilled water before and after calibration and between measurements. The pH probe was inserted into the sample, allowed to stabilize, and readings were recorded. Acidity was determined by adding two drops of phenolphthalein indicator to 100 ml of the sample and titrating with 0.02 M sodium carbonate until the colour changed from colourless to pink. For alkalinity, 100 ml of each sample was placed into a conical flask, and hydrogen chloride (0.5 M) with two drops of methyl red indicator was added until the colour changed from pink to colourless.

The gravimetric method was used to measure TDS. 100 ml of the filtered sample was dried in a water bath and then heated at approximately 180°C for one hour. The residue's mass was used to determine the TDS concentration. Total solids were estimated by drying 100 ml of the filtered sample in a crucible, and then heating it in an oven at 100°C for one hour. The residue weight divided by the sample volume and multiplied by one million gave the TS concentration.

To measure total hardness, 100 ml of the sample was placed in a conical flask. Four drops of eriochrome black T, one packet of ammonium chloride buffer solution, and 0.1 M EDTA were added. The mixture was titrated until the colour changed from red to blue, and the result was noted. For dissolved oxygen, 100 ml of the sample, 1 ml of manganese sulphate solution, and 1 ml of alkaline iodide were mixed in a reagent bottle. After settling, 2 ml of sulfuric acid was added to the precipitate. 100 ml of the solution, 2 ml of starch indicator, and sodium thiosulphate (0.02 M) were added to a conical flask and titrated until the colour changed from yellow to blue-black.

Fluoride was measured by adding and mixing fluoride tablets 1 and 2 into the sample. The colour was compared with a comparator scale to record the result. For chlorine measurement, a tablet of diethyl-p-phenylenediamine was added to the sample. The remaining chlorine was measured similarly. Nitrate analysis involved adding chromaver 3 reagents and nitrite analysis involved adding nitrate 2 powder reagents. Both analyses used a UV spectrophotometer following the APHA method (APHA 2008). To determine chloride, 100 ml of the sample and 1 ml of potassium dichromate were added to a conical flask. The solution was titrated with silver nitrate solution until the colour changed from yellow to brown.

Method Used in Water Quality Index Analysis

The quality of the water samples for consumption was evaluated using the Weighted Arithmetic Water Quality Index (WQI). Originally devised by Horton in 1965 and modified by Brown et al. in 1972, this method evaluates water quality by considering the combined effects of multiple water quality

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parameters. It categorizes water quality based on purity and provides a comprehensive assessment of surface or groundwater quality. The formula for the Weighted Arithmetic WQI is given as:

$$WQI = \frac{\sum Q_i W_i}{\sum W_i} \quad (1)$$

where Q_i stands for the scale for rating water quality and is given as:

$$Q_i = \left[\frac{V_a - V_i}{V_s - V_i}\right] x100 \quad (2)$$

V_a = actual value of water quality parameter obtained from the data,

V_i = ideal value of water quality parameter

V_s = recommended standard value of the parameter as given by WHO (2017).

RESULTS AND INTERPRETATION

The mean values of the physicochemical properties of the flowing waters collected from Ago-Iwoye, Oru, and Ijebu-Igbo are summarized in Tables 2-5. Table 2 presents the mean values of the physical characteristics of the ten water samples, labeled A-J, from these locations. Table 4 provides the chemical characteristics of the same water samples. For comparison, Tables 3 and 5 lists the permissible limits for physicochemical parameters as established by the World Health Organization (WHO), Nigeria Industrial Standard (NIS), and the National Agency for Food and Drug Administration and Control in Nigeria (NAFDAC), respectively.

Table 2: Mean Values of Physical Characterization on the Flowing Waters Collected from Ago-Iwoye, Oru and Ijebu-Igbo

S/N	Samples	Colour	Conductivity [µS/cm]	TDS [mg/L]	Turbidity [NTU]	Temp [^{0}C]	Total solids [mg/L]	TSS [mg/L]
1	**A**	45	103.80	49.80	46.30	24.00	270.00	220.20
2	**B**	50	98.70	47.30	56.70	24.70	275.00	227.70
3	**C**	70	96.60	46.10	76.10	25.20	285.70	239.60
4	**D**	25	60.40	28.70	32.90	25.00	150.00	121.30
5	**E**	100	74.90	35.80	99.40	25.30	262.50	226.70
6	**F**	25	132.40	63.80	29.40	26.10	340.00	276.20
7	**G**	100	71.80	34.40	105.00	26.20	241.70	207.30
8	**H**	15	201.00	97.30	21.30	26.20	246.00	148.70
9	**I**	20	84.00	40.30	26.40	26.70	189.20	148.90
10	**J**	15	105.40	50.30	25.50	26.00	230.00	179.70

Table 3: Drinking Water Standards: WHO, (2017), WHO, (2008), NIS (2015). NAFDAC (2001)

Parameters	Maximum permissible limit (WHO)	Maximum permissible limit (NIS)	Maximum permissible limit (NAFDAC)
Conductivity (µS/cm)	1200	1000	1000
TDS (mg/L)	1000	500	500
Turbidity (NTU)	5	5	5
Temp (^{0}C)	NA	Ambient	NA
TS (mg/L)	1500	500	500
TSS (mg/L)	-	0.1	-
Colour (TCU)	15	15	3

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Figure 2 is the pictorial representation of Tables 2 and 3 combined, where it can be seen that both panels at the top row and the first panel on the bottom row indicate the physical characterization of the ten (10) water samples are below the permissible limits of all the three standards, i.e., the WHO, NIS and NAFDAC. However, the other three characteristics, namely, turbidity, temperature and total suspended solids (TSS) are above the three standards in all the water samples. Sample H has the highest conductivity and total dissolved solids (TDS), though far below the permissible limit. The turbidity of all the samples should be "flagged red" because all the samples are above the permissible limit respectively.

Table 4: Mean Values of the Chemical Characterization of the Flowing Waters Collected

S/N	Parameters	A	B	C	D	E	F	G	H	I	J
1	**pH**	7.4	7.24	6.99	6.78	6.75	7.04	6.87	7.01	6.75	6.99
2	**Dissolved oxygen [mg/L]**	8.83	8.53	7.74	8.44	6.53	6.89	7.86	5.28	7.14	8.61
3	**Nitrate [mg/L]**	1.32	0.82	0.57	0.47	6.93	14.8	14.2	12.9	0.22	0.35
4	**Acidity [mg/L]**	0.1	0.1	0.2	0.3	0.3	0.1	0.3	0.1	0.3	0.2
5	**Iron [mg/L]**	0.6	0.5	1.2	0.4	1	1	1.5	0.4	0.3	1
6	**Nitrite [mg/L]**	0.033	0.024	0.027	0.031	0.12	0.238	0.231	0.22	0.004	0.01
7	**Alkalinity [mg/L]**	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
8	**Chlorine residual [mg/L]**	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
9	**Chloride [mg/L]**	53	48	60	47	41	73	50	108	47	58
10	**Total hardness [mg/L]**	76	85	86	54	58	106	61	141	70	99
11	**Calcium hardness [mg/L]**	38	45	46	34	29	69	44	78	43	56
12	**Magnesium hardness [mg/L]**	38	40	40	20	29	37	17	63	27	43

Table 5: Drinking Water Standards

S/N	Parameters	Maximum permissible limit (WHO)	Maximum permissible limit (NIS, 2015)	NAFDAC
1	**pH**	6.5-8.5	6.5-8.5	6.5-8.5
2	**Dissolved oxygen (mg/L)**	-	-	-
3	**Nitrate (mg/L)**	50	10-50	10
4	**Acidity (mg/L)**	0.6	-	-
5	**Iron (mg/L)**	0.3	0.3	0.3
6	**Nitrite (mg/L)**	3	0.02-0.2	0.02
7	**Alkalinity (mg/L)**	100	100	100
8	**Chlorine residual (mg/L)**	5(C)	-	-
9	**Chloride (mg/L)**	250	100-250	100
10	**Total hardness (mg/L)**	500	100	100
11	**Calcium hardness (mg/L)**	300	150	-
12	**Magnesium (mg/L)**	50	0.2-20	30

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Figure 2: The Physical Characterization of Water Samples. A – J are the Water Samples Collected While WHO, NIS and NAFDAC are the Permissible Limits by the World Health Organization, Nigeria Industrial Standard and the National Agency for Food and Drug Administration and Control in Nigeria Respectively.

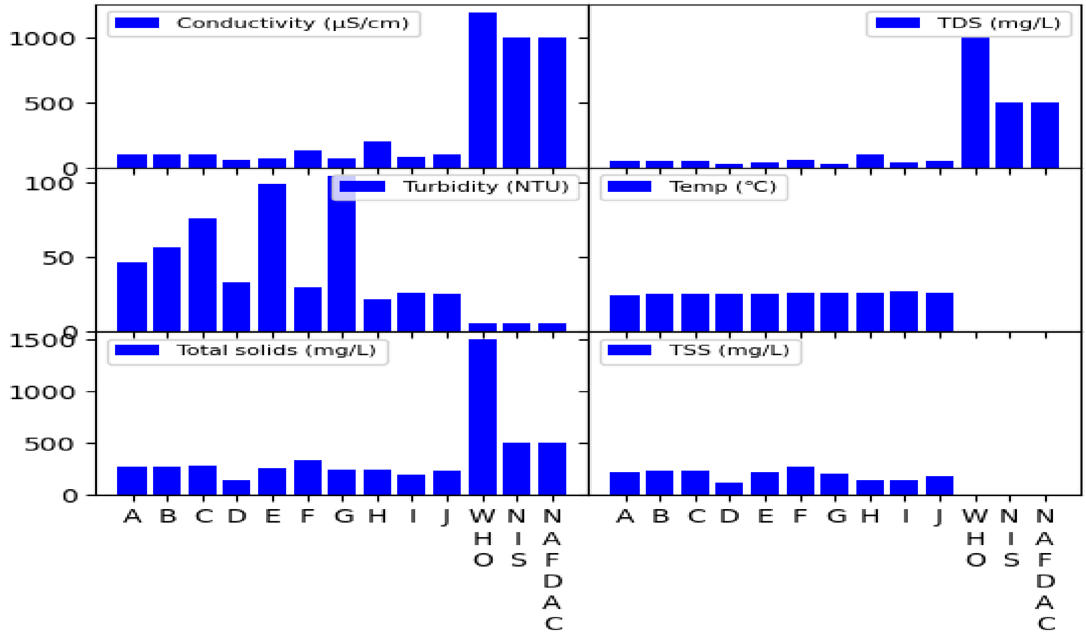

Figure 3: The Chemical Characterization of Water Samples. A – J are the Water Samples Collected. At the Same Time, WHO, NIS and NAFDAC are the Permissible Limits by the World Health Organization, Nigeria Industrial Standard and the National Agency for Food and Drug Administration and Control in Nigeria Respectively.

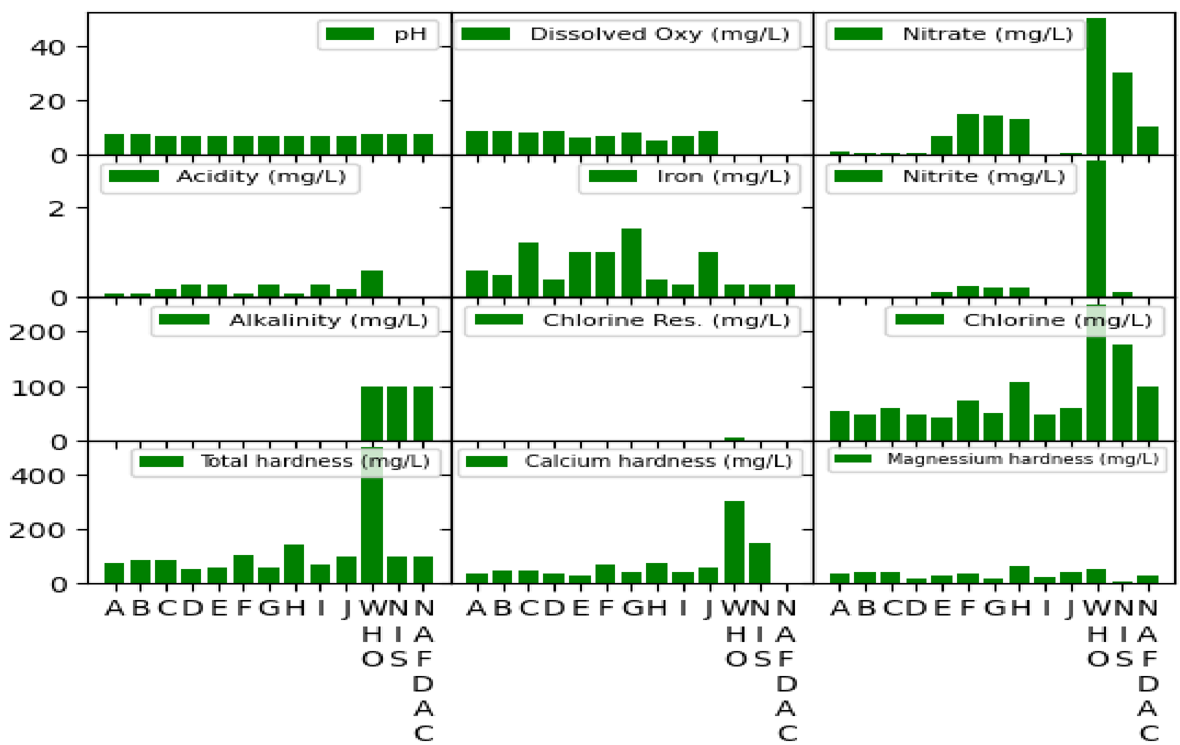

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Figure 3 depicts the chemical characterization for the ten water samples A – J shown in Table 4. A comparison between Table 5 and Figure 3 shows that while the pH of all the water samples is within the standard limits, nitrate, nitrite, acidity, alkalinity, chlorine and chlorine residue are below the permissible limits, dissolved oxygen and iron are above the permissible limit. Whereas the total hardness and the calcium hardness are below the permissible limits, the magnesium hardness left a trace to be wary of. The WQI findings for the collected sample waters are shown in Table 6 and were calculated using the following parameters: conductivity, TDS, turbidity, TS, colour, pH, acidity, calcium hardness, magnesium, chloride, iron, and nitrate. Table 6 also displays these characteristics along with their mean values (Va) in comparison to the standards (Vs) specified for drinking (WHO). The WQI assessment of the waters gathered from Ago-Iwoye, Oru, and Ijebu-Igbo is summarized in Table 7.

Table 6: Water Quality Index of the Flowing Waters Collected from Ago-Iwoye, Oru and Ijebu-Igbo

Location A

	Conductivity	TDS	Turbidity	TS	Colour	pH	Acid	Calcium hardness	Magnesium	Chlorine	Iron	Nitrate
Vi	0.000	0.000	0.000	0.000	0.000	7.000	0.000	0.000	0.000	0.000	0.000	0.000
Va	103.800	49.800	46.300	270.000	45.000	7.400	0.100	38.000	38.000	53.000	0.600	1.320
Vs	1200.000	1000.000	5.000	1500.000	15.000	8.500	0.600	300.000	50.000	250.000	0.300	3.000
Qi	8.650	4.980	926.000	18.000	300.000	26.670	16.670	12.670	76.000	21.200	200.000	44.000
1/Vs	0.001	0.001	0.200	0.001	0.067	0.118	1.667	0.004	0.020	0.004	3.334	0.334
Wi	0.001	0.001	0.035	0.001	0.012	0.021	0.290	0.001	0.004	0.001	0.580	0.058
QiWi	0.009	0.005	32.410	0.018	3.600	0.560	4.833	0.013	0.304	0.021	116.000	2.552
WQI =	**159.528**											

Location B

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	Conductivity	TDS	Turbidity	TS	Colour	pH	Acid	Calcium hardness	Magne sium	Chlo rine	Iron	Nitrate
Vi	0.000	0.000	0.000	0.000	0.000	7.000	0.000	0.000	0.000	0.000	0.000	0.000
Va	98.700	47.300	56.700	275.000	50.000	7.400	0.100	38.000	38.000	53.000	0.600	1.320
Vs	1200.000	1000.000	5.000	1500.000	15.000	8.500	0.600	300.000	50.000	250.000	0.300	3.000
Qi	8.225	4.730	1134.000	18.340	333.340	26.670	16.670	12.670	76.000	21.200	200.000	44.000
1/Vs	0.001	0.001	0.200	0.001	0.067	0.118	1.667	0.004	0.020	0.004	3.334	0.334
Wi	0.001	0.001	0.035	0.001	0.012	0.021	0.290	0.001	0.004	0.001	0.580	0.058
QiWi	0.008	0.005	39.690	0.018	4.000	0.560	4.833	0.013	0.304	0.021	116.000	2.552
WQI =	**167.169**											

Location C

	Conductivity	TDS	Turbidity	TS	Colour	pH	Acid	Calcium hardness	Magne sium	Chlo rine	Iron	Nitrate
Vi	0.000	0.000	0.000	0.000	0.000	7.000	0.000	0.000	0.000	0.000	0.000	0.000
Va	96.600	46.100	76.100	285.000	70.000	6.990	0.200	46.000	40.000	60.000	1.200	0.570
Vs	1200.000	1000.000	5.000	1500.000	15.000	8.500	0.600	300.000	50.000	250.000	0.300	3.000
Qi	8.050	4.610	1522.000	19.000	466.670	-0.667	33.340	15.340	80.000	24.000	400.000	19.000
1/Vs	0.001	0.001	0.200	0.001	0.067	0.118	1.667	0.004	0.020	0.004	3.334	0.334
Wi	0.001	0.001	0.035	0.001	0.012	0.021	0.290	0.001	0.004	0.001	0.580	0.058
QiWi	0.008	0.005	53.270	0.019	5.600	-0.014	9.667	0.015	0.320	0.024	232.000	1.102
WQI =	**300.514**											

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DISCUSSION

The conducted water quality assessment analysis was carried out using the mean values of the total samples collected. The parameters examined include conductivity, TDS, colour, PH, acidity, Calcium hardness, Chloride content, Iron content, and Nitrate content. Though aquatic life requires a minimum of 4-5 mg/L of dissolved oxygen in water, The DO parameter was not considered as there are no maximum permitted restrictions for the concentration of dissolved oxygen in water. In other words, Chaturvedi (2020) concluded that the higher the concentration of DO in a water body for aquatic life the better the water is suited for living beings.

The statistical evaluation was carried out using Microsoft Excel. The mean parameters of the sample analyzed are shown in Fig. 2 and 3. According to WHO, colour is a major parameter for portable water. Water that is considered for human domestic use is expected to be colourless and odourless. Colour in water is either a result of impurity, fine sediment (clay), or chemical substances/pollutants which are considered to negatively impact the growth of the aquatic life. Also, coloured water reduces the light penetration in a water body, which also affects the growth of aquatic plants. The result of the physical examination of the colour/appearance of each collected water sample shows that they all exceeded the required maximum set standard by the NAFDAC, SON, and WHO as shown in Table 2-5. Samples from location H were shown to have the least deviation from the set maximum standard with a mean of 13 when compared with WHO and NAFDAC.

Water conductivity is a parameter in water analysis used to determine how well it can conduct electricity. The primary influence of this is the presence of dissolved charged chemicals (chemical salt) i.e. the higher the concentration of chemical salt the higher the conductivity of the water body. Temperature and concentration of organic compounds also play a major role in the level of the water body. The higher the temperature the higher the conductivity while higher concentrations of organic matter reduce the conductivity of water. According to WHO and the United States Environmental Protection Agency (EPA), stream/river water in typical tropical climates as the study area is set to a permissible concentration of 200-1000 microsiemens per centimetre (mcg/cm). The field-measured conductivity at the different sampled locations was below the set maximum concentration of 1000 (mcg/cm) which ranges from 60.40 to 201.00 (mcg/cm). The low conductivity is attributed to high organic compounds in the body of water.

Total suspended and dissolved solids (TSS and TDS) are indicators of overall water quality. TDS indicates the amount of dissolved solids (rock minerals, soil and contaminants) in the water body and a high value could be used to indicate hard water and not necessarily that the water body is contaminated or not portable. Also, a low TDS or TSS does not mean the water body is not contaminated as TDS does not account for heavy metals like Lead, Cr and pesticides or pharmaceutical wastes. The water samples' TDS showed a minimum variation below the permissible value (500mg/L, (NAFDAC)) and it ranged from 27.6 to 98.60mg/L. High levels of TDS can affect turbidity, increase water temperatures, and decrease dissolved oxygen (DO) levels. TSS are particles in water that a filter can capture. They are found to be within 118.30–278.30 mg/L with a maximum value at location F. The total solid (TS), which is a measurement of all the suspended, colloidal, and dissolved solids in a sample of water, was found to be below the permissible limit (500 mg/L for NAFDAC; 1500 mg/L for WHO). The maximum recorded value of TS was 343.60 mg/L. Turbidity refers to the cloudiness of water caused by suspended matter such as clay, silt, organic and inorganic matter, plankton and other microscopic organisms, and light scattering and absorption. The measured values in this study ranged between 19.2 and 105.20NTU, which are above the permissible

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limit of 5NTU by NAFDAC and WHO. High turbidity significantly reduces the aesthetic quality of lakes and streams. It also harms recreation and tourism and can increase the cost of water treatment for drinking and food processing.

The acidity levels of the waters ranged from 0.1 to 0.3 mg/L, below the WHO permissible limit of 0.6 mg/L. Water hardness, expressed as calcium carbonate concentration, was measured, with locations F, H, and J exceeding the NAFDAC limit of 100 mg/L but remaining below the WHO limit of 500 mg/L. Hard water, although not seriously harmful to human health, can cause problems in industrial settings and can be corrosive if extremely low.

Calcium and magnesium hardness were below the permissible limits, except for location H, which exceeded the magnesium limit of 50 mg/L set by WHO. Chloride levels were below the permissible limit of 100 mg/L except for location H, which had a mean of 108 mg/L. Excessive chloride in water can cause an unpleasant taste and smell. Iron concentrations exceeded the permissible limit of 0.3 mg/L in most locations, with the highest at location G (1.70 mg/L). Iron is essential for human nutrition, but high concentrations can impart a metallic taste to water.

Nitrate levels were below the WHO permissible limit of 50 mg/L, but locations F, G, and H exceeded the NAFDAC limit of 10 mg/L. High nitrate levels in drinking water are associated with adverse health outcomes such as methemoglobinemia and various cancers. No traces of fluoride, chlorine residual, sulfate, silica, or potassium were detected. The WQI showed that the water bodies in the study are extremely unsuitable for domestic use. Location G had the highest WQI (411.408), indicating its unsuitability, primarily due to high turbidity and nitrate levels. The location I had the lowest WQI (92.466), rated as very poor, with nitrate, pH, acidity, total hardness, and magnesium hardness levels below permissible limits, but still not suitable for domestic use.

CONCLUSIONS

This study assessed the quality of water resources in the Ijebu North Local Government Area, revealing significant insights into their suitability for various uses. The findings indicate that while the water is largely unsuitable for domestic consumption due to high turbidity levels and the presence of certain contaminants, it remains viable for agricultural purposes.

The physicochemical analysis showed that the water samples had pH levels within the permissible limits set by WHO and NAFDAC, suggesting that the anthropogenic activities in the area, though present, are currently manageable. However, the elevated turbidity and the presence of contaminants such as nitrates and iron pose serious health risks, rendering the water unsafe for drinking without adequate treatment.

To mitigate these issues, it is imperative to implement stricter regulations on industrial waste treatment and prohibit the dumping of refuse into water bodies. Proper management and treatment of waste are essential to prevent further contamination and to protect both human health and aquatic ecosystems (Talabi et al., 2020).

Furthermore, the study underscores the importance of governmental intervention in the protection and sustainable management of natural water resources (Mamtal and Vishal, 2018). Ensuring access to clean water is vital not only for human health but also for the long-term sustainability of the environment.

In conclusion, while the water resources in Ijebu North are not currently fit for domestic use, with appropriate measures and management, the quality can be improved. This research highlights the urgent need for concerted efforts by environmental agencies, the government, and the community to safeguard water quality and ensure a healthier future for the region.

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