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COMPARATIVE ASSESSMENT OF WATER QUALITY PARAMETERS AND MICROBIAL LOADS IN SELECTED WELL WATER AS AN INDEX OF POLLUTION. A CASE STUDY OF ISEYIN, OYO STATE, NIGERIA.

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Abstract

Groundwater is an essential resource for drinking and its quality is extremely important to human health, monitoring it will offer tangible protection for man and other living creatures. This study assessed and compared water quality parameters and microbial loads in selected groundwater as an index of pollution in Iseyin, part of geopolitical zone in Oke-ogun areas of Oyo State. Water samples were collected from three different well water in Iseyin based on their nearness to dumpsites, hospital and area assumed to be clean. The physico-chemical parameters were examined using standard laboratory procedures. Heavy metal concentrations were analysed using spectrophotometry methods. Microbial loads of the water samples were examined by membrane filter and media were prepared following the manufacturer's instructions. Pollution index of water samples were determined by Arithmetic Index (WQI) and Nemerow's Pollution Index. The result showed highest turbidity values in January (A; 29.57±21.89, B; 132.17±0.29 Ntu and range of 1.77±0.15-75.33±0.58 Ntu across stations in the wet seasons. Biological Oxygen Demand values ranged from 3.60±0.00-28.43±36.52 mg/L and 4.57±0.58-14.57±0.06 mg/L across dry and wet months. Highest values of Electrical Conductivity and Phosphate across sampling stations were also recorded. Other Parameters were within the recommended limits of World Health Organization (WHO) and Nigeria Standard for Drinking Water Quality (NSDWQ). However, heavy metal concentrations revealed Lead as Below Detective Limits while its presence in some

Keywords: Contamination, WQI, Viable, Coliform Counts, Turbidity, Pb, Anthropogenic sources

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stations were higher than the limits. Zinc revealed highest values in Jan (16.17±0.15 mg/L) at station C, and May (8.80±0.10 mg/L) in station A. Copper and Iron were at peak in many stations both dry and wet months. Microbial loads revealed highest coliform and viable counts in many water samples examined. Water quality indices indicated high pollution status of the groundwater samples. The study concludes that majority of water samples examined were highly contaminated with highly suspended particles that resulted into high values of EC, nutrient influx, heavy metal contamination particularly those water samples collected near dumpsites and hospital as a result of anthropogenic impacts. This study recommends serious water treatment before consumption and regular monitoring of the water sources.

Introduction

Groundwater is one of the most sources of freshwater for domestic, Agricultural and industrial purposes, particularly in areas where surface water resources are limited (UNESCO, 2023). Its quality is influenced by the geological and hydrogeological features of an area, as well as anthropogenic activities such as Agriculture, waste disposal, industrial activities and urbanization. Nevertheless, groundwater is naturally filtered as it still become contaminated by physical pollutants (Ocheri *et al.,* 2014; Tanko *et al.,* 2024; and Thomas, 2026). Groundwater quality assessment involves the systematic evaluation of physical, chemical, and microbiological characteristics of groundwater to determine its suitability for various uses, especially drinking and domestic purposes. Deterioration of water quality with increased level of pollutants like heavy metals, pesticides from agricultural fields, human activities, microbial load that causes infectious diseases have gained attention from researchers in different locations in recent years. However, timely monitoring of these threats can protect and prevent public health such as typhoid, long term chemical toxicity and habitat degradation. Assessing groundwater quality is therefore imperative for understanding the condition of groundwater resources, identifying sources of pollution, and developing appropriate measures for their protection and sustainable management (WHO, 2022).

Abulude *et al.* (2023) reported low values of pH and high values of EC in hand-dug well compared to other water bodies studied in Ondo, Ekiti and Osun States. They associated the low values of pH in dug wells to be too acidic for human consumption because it can harm digestive or lymphatic system, however, high value of EC can result from anthropogenic activities. Casimir *et al.* (2015) also observed heavy metal assessment of groundwater and found out that Cadmium, Iron and Manganese values were more than the standard limits of potable water indicating metal pollution of the groundwater in Gombe State. These samples of groundwater are not fit for consumption except after treatment.

Egbinola and Amanambu (2014) who carried out arsenic and fluoride contamination of selected groundwater reported high concentration of arsenic compared to fluoride in the well water sampled in Ibadan. It was discovered that high values were reported during raining season and associated it to erosion/flooding and percolation. High concentration of arsenic was also reported by Garba *et al.* (2010) for tap water, hand dug wells and boreholes in karaye Local Government

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Area, Kano State. Similar observation was made by Kayode *et al.* (2011) in well water, surface water and boreholes water in Ogun State. The authors also noted that most private well owners and users are not aware of contamination problems. Study conducted in Ogbomoso among well water studied revealed highest value of nitrate to be (127.58 mg/L), acidic to basic pH and high value of chloride in one of their samples. The authors concluded that the water samples examined does not support good health (Ojoawo and Kolade, 2013).

The study carried out in Ibeju-Lekki Lagos on quality of groundwater revealed that high values of Iron and Magnesium were observed in borehole and the well water samples. Elevated values of turbidity, TDS, EC in the well water samples were an indication of presences of pollutants in the water source (Chiemeka and Obong, 2003). Variation in well water and Borehole water quality parameter is an indication of organic pollution, suggestion was made for chemical treatment of water before drinking. Okareh *et al.* (2023) in their assessment of heavy metal contamination of Groundwater in South Western Nigeria reported lower pH values that can cause acidosis which are linked to skin and eye discomfort (Meinhardt, 2006; Longe and Balogun, 2010).

Emmanuel *et al.* (2015) in their study of well water in Samaru observed high coliform count more than the limits across the well-water sampled. They also reported that all well water examined contained one or more bacterial pathogens, such as *Escherichia coli* (20%), *Klebsiella pneumoniae* (100%), and *Proteus mirabilis* (40%) while observation of *Shigella, Salmonella* and *Vibrio* species were not notified. It was revealed that majority of the well water contaminated were of faecal origin indicating the water sources as a sources of water-borne diseases outbreak and that the water is not fit for drinking.

Regular monitoring also provides valuable information for preventing public-health problems and ensuring the availability of safe and suitable water for the present and future generations (Belitz, 2022). An assessment limited to a few physico-chemical parameters may not provide sufficient information about the overall condition of a groundwater source. Hence, reason for examining different parameters in the recent study to capture varied sources of groundwater pollution. Therefore, the present study was designed to examine the pollution index of selected well water samples in Iseyin area of Oyo state.

Materials and Methods

Description of Study Area: Iseyin is a prominent city and local government area in Oyo State, Southwestern Nigeria, located about 100 kilometers (62 miles) North of Ibadan. It serves as a major commercial and administrative hub and the headquarters of the Oke-Ogun region. The land area spans roughly 1,419 to 2,341 square kilometers, featuring a mix of derived savanna, tropical forests, and nearby inselbergs. Iseyin is widely celebrated as the capital or "Home of Aso Oke" (Aso Ofi), the prestigious handwoven traditional textile of the Yoruba people. The town hosts an annual Aso-Ofi Festival to celebrate its master weavers. Iseyin is also known as part of the "food basket" of the region, its fertile land supports the cultivation of yam, cassava, maize, tobacco, cashew, and cotton. Key local features include the Ikere Gorge Dam, the Raji Oke-Esa Digital Library, the Ebedi Writers' Residency, a campus of Ladoke Akintola University of Technology (LAUTECH), and proximity to the Ado-Awaye Suspended Lake. Traditional crafts like indigo dyeing and cotton spinning also anchor the local economy. The Geographical setting, climatic conditions and human

activities within Iseyin are important consideration in groundwater quality assessment because they may influence groundwater recharge and the potential introduction of contaminants into the well water resources (Ogundele, 2022).

Sampling Techniques and Duration: Well water samples were collected during the dry season (December - February, 2026) and wet season (April - June, 2026). Water samples were collected from three (3) locations in each geopolitical zone of Oyo State, once in a month, resulting in a total of eighteen (18) samples across sample locations. The sample locations were selected based on some ecological features such as nearness of groundwater to waste dumpsite, hospital, and natural ecosystem not fully disturbed by anthropogenic activities.

Sample Treatment: Water samples were randomly collected from different locations/sites using Polypropylene bottles. Each water sample was treated with 2 mL of concentrated HNO_3 per litre sample and tightly capped to preserve the integrity of the sample until ready for use in the laboratory for analysis.

Well water Sample Collection and Determination of Water Quality Parameters: Well water samples were collected in pre-labelled 5-litres plastic kegs. Some physical parameters such as temperature and pH were measured in-situ using a pH meter and a mercury in-glass thermometer respectively. Other water quality parameters, including Electrical conductivity, Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Nitrate (NO_3^-), Phosphate (PO_4^{3-}), Total Dissolved Solids (TDS) were examined using standard laboratory procedures of Ademoroti (1996).

Determination of Heavy Metal Concentrations: The heavy metals examined for the purpose of this study were Copper (Cu), Zinc (Zn), Iron (Fe), Lead (Pb) etc. The stock solutions (1µg/ml) of each of the metal ions mentioned above were prepared using appropriate metal salt of Analytical Grade quality in dilute Hydrochloric acid (HCL). The working standard of these solutions was prepared by appropriate dilutions in distilled water. The water samples were analysed for heavy metal concentrations using inductively Coupled Atomic Absorption Spectrophotometers (ICF-AAS Model Drawell M/S)

Determination of Water Quality Parameters of each Sample Stations: Water quality parameters of each station was determined using weighted Arithmetic WQI according to the Brown *et al.* (1972). The formula for calculation are as follows:

Step 1: calculation of the unit weight (Wn) factor for each parameters using formula

$$Wn = k/Sn$$

where $K = \dfrac{1}{1/S1 + 1/S2 + 1/S3 + 1/S4 ..... 1/Sn}$

Where Sn= Standard desirable value of the nth parameters on summation of all selected parameters, unit weight factor (Wn) =**1**

Step 2: Calculation of Sub-index (Qn) value using formula

$$Qn = \frac{[Vn - Vo]}{[Sn - Vo]} x100$$

Where Vn=mean concentration of the nth parameters

Sn=Standard desirable value of nth parameters

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Vo=Ideal values of the parameters in pure water, (generally, Vo=0 for most parameters except pH). Therefore, QpH= $\frac{[VpH-7]}{[8.5-7]}x100$

Step 3: Combination of step 1&2 will give WQI value as

WQI=∑WnxQn

The exact parameters that causes pollution of the groundwater can also be determined using Nemerow's Pollution Index (1970) as :

NPI= $\frac{Cn}{Sn}$ Where

Cn = concentration of the nth parameters

Sn= Prescribed Standard limits of the nth parameters

Determination of Bacteria Load /Coliform Count

Preparation of MacConkey Broth: The media were prepared according to the manufacturer's instruction. MacConkey broth was used as a differential medium for detection and enumeration of coliforms from water samples collected.

Procedure: The sterile water samples were collected and filtered through a membrane, followed by incubation of the filtered water on a selective medium, and the resulting colonies were later counted to determine the number of viable counts and coliform bacteria per 100m/L of water sample.

Results

Table 1a: Mean ± SD Values of Physico-chemical Parameters of Dry Months of Iseyin Water samples

MONTHS/STATIONS		DEC.			JAN.			FEB.				
Sample Stations	Parameters	A	B	C	A	B	C	A	B	C	WHO	NSDWQ
	Temperature (°C)	27.0±0.00	27.33±0.33	28.0±0.00	28.0±0.00	26.5±0.00	25.0±0.00	25.0±0.00	25.60±0.00	27.8±0.00	ambient	ambient
	pH (mg/L)	8.2±0.00	7.6±0.00	7.67±0.66	7.6±0.00	7.6±0.00	7.0±0.00	7.5±0.00	7.6±0.00	7.0±0.00	6.5-8.5	6.5-8.5
	DO (mg/L)	4.40±0.20	5.67±0.06	5.53±0.06	4.27±0.12	5.87±0.06	5.73±0.15	16.02±0.00	4.20±0.00	2.50±0.00	4 - 6	5.0
	BOD (mg/L)	6.53±0.06	28.43±36.52	28.43±36.52	6.23±0.06	6.41±0.02	7.10±0.18	3.60±0.26	4.90±0.00	5.27±0.12	0 - 2	< 5
ISEYIN	EC (µs/cm)	2763.33±577.70	3940.00±0.00	4173.33±5.77	4066.67±11.55	4140.00±0.00	1280.00±0.00	2008.00±0.00	1806.00±0.00	3333.33±152.75	1000 - 1500	1000
	TDS (mg/L)	176.00±0.00	120.00±0.00	76.33±0.58	16.33±0.06	10.53±0.06	48.80±63.39	149.67±2.08	122.00±0.00	77.33±1.53	500-1000	500
	Nitrate (mg/L)	136.00±34.64	109.00±0.00	11.67±0.12	109.53±0.12	8.90±0.00	114.00±0.00	116.00±0.00	126.00±0.00	13.43±0.06	50	50
	Phosphate (mg/L)	17.60±0.00	16.90±0.00	0.60±0.00	114.27±0.23	0.05±0.00	128.00±0.00	1.47±0.25	0.67±0.12	0.20±0.00	5	0.3 – 5.0
	Turbidity (NTU)	2.60±0.00	5.50±0.00	1.60±0.00	29.57±21.89	132.17±0.29	16.30±0.17	5.37±2.97	11.83±0.12	10.50±0.00	5.0	5.0

Keys

A= Water samples from well water near the Dumpsite **B**= Water samples from well water near The Hospital **C**= Water samples from well water in a Natural Environ. **WHO**=World Health Organisation, **NSDWQ**=Nigeria Standard for Drinking Water Quality

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Table 1b: Mean ± SD Values of Physico-chemical Parameters of Rainy Months of Iseyin Water samples

MONTHS/STATIONS		APRIL.			MAY			JUNE				
Sample Stations	Parameters	A	B	C	A	B	C	A	B	C	WHO	NSDWQ
	Temperature (°C)	27.80±0.00	27.40±0.00	27.00±0.00	27.80±0.00	27.50±0.00	28.50±0.00	27.60±0.00	27.00±0.00	27.10±0.00	ambient	ambient
	pH (mg/L)	7.50±0.00	7.80±0.00	7.00±0.00	6.90±0.00	7.50±0.00	7.00±0.00	6.50±0.00	7.50±0.00	7.10±0.00	6.5-8.5	6.5-8.5
	DO (mg/L)	8.87±0.06	10.80±0.00	7.43±0.06	2.33±0.06	2.83±0.06	1.89±0.00	6.57±0.06	7.40±0.10	1.59±0.09	4 - 6	5.0
ISEYIN	BOD (mg/L)	6.50±0.00	7.87±0.06	6.60±0.00	4.57±0.58	11.33±1.15	14.57±0.06	4.73±0.06	6.90±3.46	5.50±0.00	0 - 2	< 5
	EC (µs/cm)	6421.33±1.15	6002.33±0.58	2041.00±1.00	1250.00±0.00	1008.67±0.58	2300.00±0.00	3925.33±0.58	1300.00±0.00	707.67±1.53	1000 - 1500	1000
	TDS (mg/L)	305.00±0.00	208.00±0.00	104.00±0.00	172.33±0.58	140.00±0.00	212.00±0.00	20.60±0.00	19.07±0.58	6.60±0.00	500-1000	500
	Nitrate (mg/L)	15.20±0.35	13.27±0.31	10.20±0.00	18.00±0.00	22.33±0.58	11.60±1.77	2.60±0.00	1.80±0.00	0.70±0.00	50	50
	Phosphate (mg/L)	1.47±0.06	1.50±0.52	0.50±0.00	14.33±0.58	4.00±2.00	1.80±0.00	3.37±0.12	1.40±0.17	0.23±0.15	5	0.3 – 5.0
	Turbidity (NTU)	18.47±0.55	14.00±2.00	2.37±0.32	1.77±0.15	14.33±0.58	11.63±0.55	75.33±0.58	23.00±1.00	18.53±0.84	5.0	5.0

Keys

A= Water samples from well water near the Dumpsite **B**= Water samples from well water near The Hospital
C= Water samples from well water in a Natural Environ. **WHO**=World Health Organisation, **NSDWQ**=Nigeria Standard for Drinking Water Quality

Table 2a: Mean ± SD Values of Heavy Metal Concentration of Dry Months of Iseyin Water sample

MONTHS/STATIONS		DEC.			JAN.			FEB.				
Sample Stations	Parameters	A	B	C	A	B	C	A	B	C	WHO	NSDWQ
	Zinc Zn (mg/L)	1.73±0.16	2.50±0.00	0.81±0.02	4.37±0.06	5.20±0.00	16.17±0.15	5.70±0.10	0.80±0.10	1.13±0.21	3 -5	3.0
ISEYIN	Copper Cu (mg/L)	6.30±0.00	11.63±0.31	16.50±0.00	1.70±0.00	2.02±0.00	1.81±0.01	0.20±0.17	0.36±0.26	1.33±0.06	2.0	1.0
	Iron Fe (mg/L)	14.53±0.06	1.80±0.00	2.50±0.00	6.43±0.23	4.50±0.17	4.77±0.23	6.67±0.12	3.33±0.15	1.77±0.15	0.2	0.3
	Lead Pb (mg/L)	0.07±0.01	0.03±0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01	0.01

Keys

A= Water samples from well water near the Dumpsite **B**= Water samples from well water near The Hospital
C= Water samples from well water in a Natural Environ. **WHO**=World Health Organisation, **NSDWQ**=Nigeria Standard for Drinking Water Quality

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Table 2b: Mean ± SD Values of Heavy Metal Concentration of Dry Months of Iseyin Water samples

MONTHS/STATIONS		APRIL			MAY.			JUNE.				
Sample Stations	Parameters	A	B	C	A	B	C	A	B	C	WHO	NSDWQ
	Zinc Zn (mg/L)	0.23±0.06	0.01±0.01	0.52±0.03	8.80±0.10	1.27±0.12	2.60±0.00	4.70±0.10	2.60±0.00	BDL	3 -5	3.0
	Copper Cu (mg/L)	0.73±0.06	0.33±0.15	BDL	1.73±0.06	4.73±0.06	2.60±0.00	3.00±0.10	0.73±0.06	BDL	2.0	1.0
	Iron Fe (mg/L)	2.63±0.06	2.18±0.00	2.93±0.06	2.63±0.06	4.33±0.06	4.30±0.30	3.70±0.00	1.60±0.00	0.43±0.06	0.2	0.3
ISEYIN	Lead Pb (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	0.07±0.00	BDL	BDL	0.01	0.01

Keys

A= Water samples from well water near the Dumpsite **B**= Water samples from well water near The Hospital

C= Water samples from well water in a Natural Environ. **WHO**=World Health Organisation, **NSDWQ**=Nigeria Standard for Drinking Water Quality

Table 3: Seasonal Variations of Viable and Coliform Counts of Microbial Load Isolated from Iseyin water Samples

Samples/Months/ Coliform Counts	Viable Counts					
Sampling Stations	A	B	C	A	B	C
December 2025	TNTC	TNTC	TNTC	01	06	06
January 2026	04	23	TNTC	03	TNTC	32
February	18	TNTC	24	15	10	02
April 2026	TNTC	---	08	TNTC	---	10
May 2026	TNTC	TNTC	TNTC	TNTC	19	TNTC
June 2026	20	10	---	06	TNTC	----

Keys

TNTC---Too Numerous to Count.

Table 4: Showing Result of Water Quality and Pollution Indices

Months/WQI	Station A	Station B	Station C
December	164.88	287.35	173.75
January	823.31	756.10	824.02
February	68.29	107.44	87.47
April	149.94	136,33	52.03
May	116.04	166.90	152.27
June	467.14	174.62	132.22
Months/NPI	**Station A**	**Station B**	**Station C**
December	34.64	8.65	11.94
January	16.72	19.03	18.55

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Months/NPI	Station A	Station B	Station C
February	15.87	7.97	4.30
April	6.39	5.31	6.98
May	6.35	10.39	10.31
June	11.11	3.91	2.67

Table 5: WQI and NPI Interpretation

WQI Values	Water Quality Classification	NPI Interpretation
0-25	Excellent	**NPI <0.0:** Clean/Unpolluted
>25-50	Good	**0.0<NPI <1.0:** Low Pollution
>50-75	Poor	**1.0 < NPI<2.0:** Moderate Pollution
>75-100	Very Poor	**2.0<NPI <3.0:** High Pollution
>100	Unsuitable for Drinking	**NPI>3.0:** Very High Pollution (Poses health risk like Blue Baby Syndrome)

Seasonal Variation of Mean Values of Physico-chemical Parameters of Selected Water Samples in Iseyin

The temperature mean values of water sampled ranged from 25.00±0.00 – 28.00±0.00^{o}C acros station in the dry months while that of rainy months ranged from 27.00±0.00 – 28.50±0.00 ^{o}C across sampled stations and are within the standard limits of drinking water. Hydrogen ion concentration of dry months were from neutral to alkaline (7.00±0.00 -8.20±0.00 mg/L) while that of rainy months ranged from acidic to alkaline (6.50±0.00 -7.80±0.00 mg/L), though they all fall within the permissible levels. Dissolved Oxygen (DO) mean values were within the acceptable limits across stations except station A (16.02±0.00), water sample of water near dumpsite was very high more than the limits set for drinking water, while that of wet months mean values were higher except stations A (2.33±0.00 mg/L), B (2.83±0.06 mg/L), C (1,89±0.00 mg/L) in the month of May and Station C (1.59±0.09 mg/L) in June which are within the permissible limits of drinking water. All mean values of Biological Oxygen Demand (BOD) were very high across stations in the dry months ranged from (3.60±0.26-28.43±36.52 mg/L) and wet months ranged from (5.50±0.00-14.57±0.06 mg/L) respectively, and were more than the required limits for drinking water across the sampled stations. Electrical Conductivity (EC) mean values were very higher in all stations except station C (1280.00±0.00 µs/cm) in January while station A (1280.00±0.00) and station B(1008.67±0.58µs/cm) mean values in May collection, while June collection mean values in B (1300.00±0.00µs/cm) and C(707.67±1.53µs/cm) were to be within the limits for drinking water. All mean values of Total Dissolved Solids (TDS) were within the limits of standard for drinking water across all stations both in dry and wet months. All Nitrate mean values were within the required limit of drinking water standard across stations and dry and wet months. Mean values recorded for Phosphate across dry months were higher except for station C (0.06±0.00 mg/L) in Dec, B (0.05±0.00 mg/L) in January while lower values that fall within limits were also recorded in February across stations. Lower mean values of phosphate across stations and wet months were also recorded except station A

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(14.33±0.58 mg/L) in May collection that were at peak more than the limits expected. All mean values of Turbidity were higher across stations of dry months except station A(2.60±0.00 Ntu), C(1.60±0.00 Ntu) in December water samples, while April station C (2.37±0.32 Ntu) and may station A(1.77±0.15 Ntu) also recorded lower values that fall within the required limits in wet months.

Mean Concentrations of Heavy Metal Across Sample Stations in Iseyin Sampled Water

Zinc concentration across stations were within the limits of drinking water standards except stations B (5.20±0.00 mg/L) and C (16.17±0.15) in January and station A (5.70±0.10 mg/L) in February with high values more than the limits expected. Station A(8.80±0.10 mg/L) in May has high values, other stations had values that are within the recommended limits. Copper values in December across its stations were higher compared to other stations in the dry months, while stations B (4.73±0.06 mg/L) and C (2.60±0.00 mg/L) recorded high values of copper in May, but other stations with lower values. All iron mean values across stations in the dry and wet months were more than the required limits. All lead mean values across stations of wet months were below detective limit but stations A (0.07±0.01mg/L) and B (0;03±0.01 mg/L) in December revealed high values more than recommended values.

Seasonal Variation of Microbial Load Encountered and Water Quality Indices in Iseyin Water Samples

Microbial load across dry months were many and many stations have too numerous to count organisms, except station A in December with 1cfu/ml, others were more than 0/100ml standard limits. Rainy season also revealed more microbes numerous to count, except station B in April with no organisms and station C in June 2026 water sample collection. Water quality index revealed WQI ranged from 68.28 to 824.02 and 52.03 to 467.14 across stations of dry and wet months respectively, which is rated as poor to an unsuitable water for drinking, except station C in April which revealed poor or moderate pollution. Nemerrow's Pollution Index (NPI) revealed 4.30-34.64 and 2.67 to 11.11 across stations of both dry and wet months, showing high pollution index. Phosphate, conductivity, turbidity and heavy metals were the major parameters that play the role in the contamination of the studied groundwater. Generally, water quality indices have higher values across the dry months than wet months, implies that season also have impact on the result.

Discussion

The temperature values that fell within the range across the sampling stations which also fell within standard values may be due to ambient condition of the environment where the water samples were collected which is suitable. Similar observation was reported by Ganiyu *et al.* (2017) in their study. Deviated result was reported by Ameh *et al.* (2022), who observed high temperature more than the standard limits in their water samples and associated it to the groundwater samples in close proximity with Dangote cement factory in their study area.

The pH values of the sampled water that were neutral to alkaline may be due to soil texture of the well water or content dissolved in it such as carbonate, calcium or magnesium deposited in the groundwater samples. This result is similar to that of Ondieki *et al*. (2021) who also reported acidic to alkaline pH in Eastern Africa in the drinking water examined. High pH values in December for

water samples near dumpsite can be attributed to dissolved effluents from the site that percolates into the water ground. Similar observation was reported by Ganiyu *et al.* (2017) who reported higher levels of pH range of 8.32-9.42 mg/L in their study of Assessment of groundwater samples near Lead smelting areas in Nigeria.

The Dissolved Oxygen that was very high in the water samples collected near dumpsite can be due to organic waste effluents percolating into the water bed and influence of high temperature during dryness. High DO values across wet months could be associated with influx from dirty areas. Ameh *et al*. (2022) reported contrary report of DO that were within the limits of drinking water in their study of assessment of groundwater near Dangote cement factory. High BOD values in the dry months may be associated with high temperature and organic influx as a result of runoff during wet seasons. The present report is in line with the observation of Babalola *et al.* (2026) who also reported high values of BOD particularly during the months of dry season.

Electrical Conductivity is the concentration of soluble salts in water which can affect the taste of any drinking water. (EC) values of the present study across the sampled stations that were very high may be due to dissolved carbonates from rocks or runoff of the surroundings of the groundwater samples. This result is similar to the report of Joseph (2021) and Sahay and Kumar (2025) who also observed high values of EC across their station sampled in Yobe State. However, Addisie (2022) and Yohanna and Abdul reported contrary observation of low values of EC in their studies.

The TDS values across the sample stations were within the recommended limits, though high values during dry months can implicate high temperature, reduced levels of groundwater. However, low values recorded for assumed clean environment water samples may be attributed to no anthropogenic impacts on the groundwater samples. The present result corroborates that of Ganiyu *et al.* (2017), Nofiu and Gbadebo (2024) who reported moderate Total Dissolved Solids that were within the standard limits of WHO in their study areas. Contrary report of high TDS was observed by Sahay and Kumar (2025) in their study sites.

Nitrate values that recorded high values during dry months in stations very close to the dumpsite and hospital could be due to dryness, influx of nutrients and effluents with low water to neutralize it that resulted into high concentration of nitrate. Skyrocketed levels of nitrate can impair health such as **Blue Baby** syndrome (Methemoglobinemia) particularly for infant under 6 months. Chronic exposure to elevated nitrates in the drinking water for years may have potential links to colorectal cancer, thyroid diseases etc. Similar observation was observed by Joseph (2021). AbdalKarem *et al.* (2026) also reported high values of Nitrate, while Zirra *et al.* (2026) reported low values within the limits at Markafi, Kaduna State.

Highest values of phosphate in the water samples near the dumpsite and hospital during dry months could be attributed to influx of effluents from the waste in the areas and influence of the dry season. High phosphate in drinking water can acute direct poisoning on human health and eutrophication on surface water which can lead to anoxic condition in the water bodies and indirectly can cause death of organisms. Gyar and Nagogo (2024), Yohanna and Abdul (2025) reported similar observation in their study areas. Nevertheless, contrary values of low phosphate were reported by Ameh *et al.* (2022) and Gopi *et al.* (2023).

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Turbidity is the suspended particles in water, usually cause cloudness or unclarity of water and usually high values can make water unfit for drinking and changing in taste due to particles dissolved in it. The present study that recorded high values of turbidity in January and February in all stations could be associated with harmattan air that usually carry particles or wind waves that can carry sand around the groundwater particularly the dumpsite areas. All turbidity values were at hike in all stations during rainy months could be attributed to erosion, influx of flood into ythe water table. Same observation of high values of turbidity were reported by Gyar and Nagogo (2024), Sahay and Kumar (2025) in their studies. However, low values were also observed by Idowu *et al.* (2026) and Syafrizah *et al.* (2024) during their investigation.

Zinc that reported high values in January could be due to dryness or deposition from the groundwater rocks, low values in all stations during the rainy months except for water samples near the dumpsites in May and June with high values, may be due to waste effluents that percolates into the well water. High level with long term exposure can impair health by causing stomach cramps, nausea and vomiting, corrosion of pipes, change in taste and odour of water. Copper, Iron and Lead that have high values could be associated with deposition from groundwater rocks, influx during rainy season and effluents dissolved from the dumpsites. Though Pb were below detection limits in many stations across the dry and wet months. Deviated report of values of Pb and Zn within the WHO limits for drinking water were reported by Oyelakin *et al.* (2020) in water sources from household in Ibadan, Ganiyu *et al.* (2017) reported high values of Pb in about 5 samples of groundwater near the lead smelting areas in examined in Southwest. Nofiu and Gbadebo (2024) also reported Iron values more than limits in their study in Abeokuta, Ogun State, Gopi *et al.* (2023) also reported below detection limits of Pb in India. High values of Pb and other metals were observed by Yussuf and Yahaya (2026) in Sabo Gari, Kano and they associated the high values to the groundwater closed to waste dumpsite.

The high total viable and coliform counts that are too numerous to count and more than required limits in drinking water across stations and wet and dry months may indicated groundwater contamination across samples. This could be traced to the nearness of the groundwater to hospital, waste dumpsite which may cause the effluent to seep down the water tables. Intake of coliform in drinking water naturally has no direct impact on human health but if there are pathogens travels with it, can cause serious waterborne illness. Symptoms include stomach cramps, nausea, vomiting, fever, watery or bloody diarrhea. This study is in line with Gyar and Nagogo (2024) that reported high total coliform and viable counts in drinking water studied in Nasarawa State. The present result also corroborated that of Ozoffor (2025) that observed highest coliform counts more than required limits in drinking water sources in Enugu State. Syafrizah *et al*. (2024) also observed similar result. The calculated WQI and NPI that exhibited spatial and temporal variations may be associated with the influence of seasons. This result is similar to the report of Abayneh (2025) and Bouchra *et al.* (2025) who reported high values of WQI across sample water. They also reported high values of WQI in rainy months than in dry months for groundwater samples examined and related it to infiltration during wet months. Abayneh (2025) also reported turbidity, TC, FC, PO4, Mg and EC as major pollutants in their NPI observed values of stations studied in Ethiopia.

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Conclusion

Groundwater samples were collected for six months considering the wet and dry seasons, physical and chemical parameters examined revealed values that were within standard limits of drinking water, except turbidity, conductivity, Biological Oxygen Demands with high values. However, Copper, Iron and lead also had high levels across stations and months, particularly water samples collected near dumpsite and hospital. Microbial counts were at highest more than the required limits in all stations, except some areas free of dirt that revealed no coliforms. Water quality index showed that majority of the water samples collected were highly polluted, while some are unsuitable for drinking at all. The contamination of the groundwater examined according to NPI result is linked to high values of phosphate, Pb, Cu, Iron, BOD and Conductivity across sample stations and months. The study concludes that the groundwaters are highly polluted due to high suspended particles as a result of human activities surrounding the groundwater. Hence, there is need for water monitoring and intervention from the Government by providing potable water to the affected town. There should be public awareness on the distance needed to cover before digging their well water near the dumpsites and hospitals and proper ways of waste management.

Declaration of Conflict of Interest

The authors declared no conflict of interest as far as this study is concerned

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