International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 01 Jan. 2025, pp: 287-291 www.ijaem.net ISSN: 2395-5252

Analysis of Physicochemical Parameters to Evaluate the Drinking Water Quality in Kauru Local Government Area of Kaduna State, Nigeria

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Date of Submission: 10-01-2025 Date of Acceptance: 20-01-2025

ABSTRACT
This research evaluates the physicochemical parameters of hand-dug well water in Kauru Local Government Area (LGA), Kaduna State, Nigeria, to assess its compliance with World Health Organization (WHO) standards for potable water. Eleven wards were sampled and analyzed for pH, electrical conductivity (EC), turbidity, total hardness, total dissolved solids (TDS), and major ions such as chloride (Cl^-), nitrate (NO_3^-), phosphate (PO_4^{3-}),and sulfate (SO_4^{2-}). Results revealed significant variations in water quality, with parameters like turbidity and EC exceeding WHO limits in several wards. These findings highlight potential risks to public health and the need for urgent water quality management strategies. It is therefore recommended that community-based water quality monitoring programs and effective water treatment systems be implemented to ensure safe drinking water for the population of Kauru LGA.

Keywords: Physicochemical parameters, water quality index, WHO, Kauru Local Government Area, hand-dug well water.

I. INTRODUCTION

Access to clean and safe drinking water is essential for sustaining life and promoting public health. According to the World Health Organization (WHO), approximately 2 billion people globally consume water contaminated with feces, which can transmit diseases such as diarrhea, cholera, and typhoid. The quality of drinking water is primarily determined by its physicochemical and microbiological properties, including pH, turbidity, conductivity, and the presence of heavy metals or harmful substances.

In Nigeria, rural communities like Kauru Local Government Area (LGA) in Kaduna State predominantly rely on surface water, boreholes, and wells for their water supply. However, these sources are often unmonitored, making them vulnerable to contamination from agricultural runoff, poor waste management, and other anthropogenic activities. Despite the critical role of water quality assessments in safeguarding public health, there is limited data on the physicochemical parameters of drinking water in Kauru LGA.

This study aims to analyze the physicochemical parameters of hand-dug well water which is the primary source of drinking water inKauru LGA, comparing the results with WHO standards to assess their suitability for human consumption. The findings will contribute to a better understanding of water quality in the region and provide actionable recommendations for improving water safety.

STATEMENT OF THE PROBLEM

The availability of safe drinking water is a fundamental human right. However, in Kauru Local Government Area of Kaduna State, residents heavily depend on untreated or minimally treated water sources. The absence of regular monitoring and quality assessment increases the risk of exposure to hazardous substances, including high levels of total dissolved solids, turbidity, and heavy metals, which can have severe health implications.

Globally, the WHO recommends that drinking water pH should range from 6.5 to 8.5, and levels of total dissolved solids (TDS) should not exceed 1000 mg/L to ensure safety and palatability. Despite these benchmarks, there is no comprehensive data on the compliance of drinking water sources in Kauru LGA with these standards. This knowledge gap underscores the urgent need for a systematic evaluation of the physicochemical parameters of drinking water in the region.

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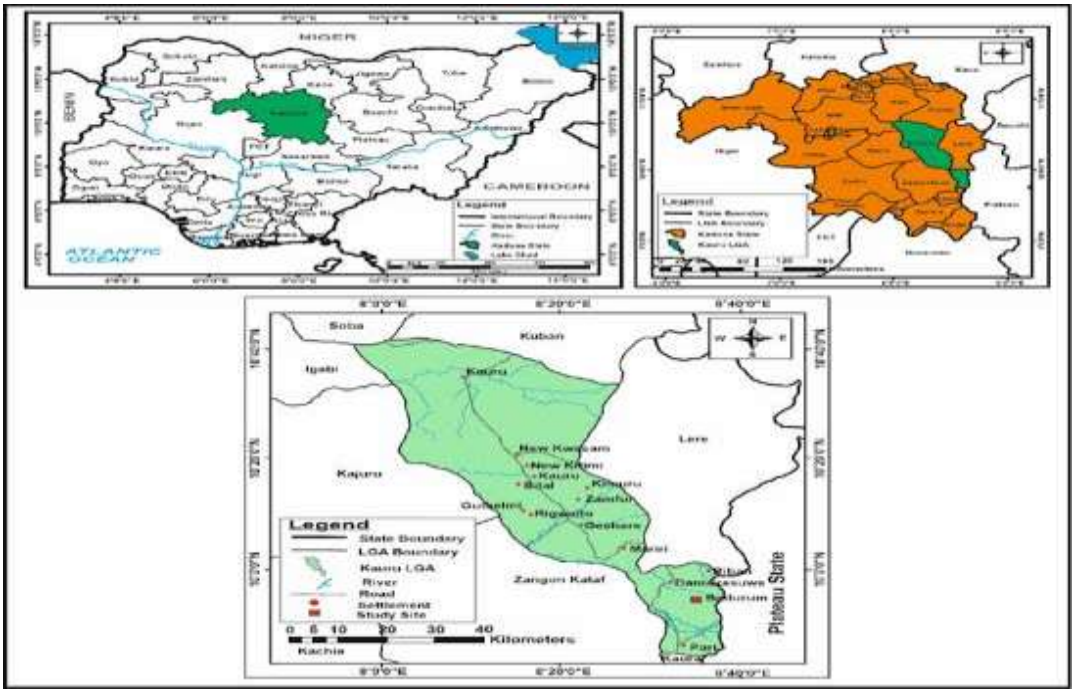
OBJECTIVE OF THE STUDY

The primary objective of this study is to evaluate the physicochemical quality of drinking water sources in Kauru Local Government Area of Kaduna State, Nigeria. The specific objectives are:

1. To measure key physicochemical parameters (e.g., pH, turbidity, conductivity, and TDS) of water sources in Kauru LGA.
2. To compare the results with WHO standards for drinking water quality.
3. To identify potential sources of contamination.
4. To provide recommendations for improving water quality and management in the region.

II. MATERIAL AND METHODS

Study area



Map Showing Study Location of Kauru Local Government Area

Kauru Local Government Area (LGA) is situated in southern region of Kaduna state, Nigeria, and is bordered by several other local government areas, includingZangonKataf LGA to the Southwest, Kajuru, Igabi, and Soba LGAs to the northwest, Kubau LGA to the north, Lere LGA to the northeast, Kaura LGA to the south; and Bassa and Riyom LGAs of Plateau State to southeast, respectively.

It has a geographical coordinate of 10°39'N 8°9'E. The area has a population of 221,276 (NPC, 2006) it covers approximately 3,186 square kilometers (km^2). It is characterized by diverse topography and climate which significantly influence its water resources, making it a key location for studying water quality in relation to public health.

Sample collection

Water samples from hand–dug wells were purposively collectedfrom 11 representative sourcesfrom residential areas of Kauru Local Government Area of Kaduna State, Nigeria.Sampling was conducted using clean, sterile 1-liter polyethylene bottles, following WHO guidelines for water sampling.The collection took place on the 15th of every month for a period of six months (July to December2024).

The samples collectedwere systematically labeled as; Bad Sam, Bit, Dam, Dam, Ges, Kam, K1, K2, Kw, MAK, Par, representingBadurumSama, Bital, Damakasuwa, Dawaki, Geshere, Kamaru, Kauru East, Kauru West, Kwassam, Makami and Pari respectively.

During the collection, various physical parameters were measured in-situ, including

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temperature, turbidity, pH, EC, additionally other chemical parameters such as nitrates, sulphates, phosphate, chloride, magnesium, total hardness, total dissolved solids, fluorides, and calcium were analyzed using the standard method for evaluating water quality (WHO, 2006).

Table 1.0:WHO Standard Classification of Water Quality Status

S/N	WQI Value	Water Quality Classification
1.	0-25	Excellent water quality
2.	26-50	Good water quality
3.	51-75	Poor water quality
4.	76-100	Very poor water quality
5.	> 100	Unsuitable for drinking

III. RESULT AND DISCUSSION

The analysis of physicochemical parameters of drinking water quality in KauruLGA revealed the levels of compliance with the World Health Organization (WHO) recommended limit for safe drinking water. As shown in the table 2.0 below:

Table 2.0: Physicochemical Parameters of Hand-Dug Well Water in Kauru LGA

Parameters	Bad Sam	Bit	Dam	Daw	Ges	Kam	K1	K2	Kw	MAK	Par
pH	6.72	7.79	7.37	7.54	7.01	7.10	7.10	7.08	7.40	6.85	6.58
EC(µS/cm)	905.67	376.67	323	351.67	358	820	217	663.67	7.66	136	217
Turb (NTU)	2.07	12.58	7.87	7.83	13.52	5.23	0.69	7.50	7.58	53.74	5.20
T.A (mg/L)	204.13	224.17	215	170	246.67	196.9	165	200.00	118.33	87.50	167
T.H (mg/L)	334.00	143.33	141	122	202	239.67	99.17	286	100.83	54.67	55.00
TDS (mg/L)	457.00	190.50	162.33	180	183.17	397.50	105.5	308.50	93.83	65	94.00
Cl^-(mg/L)	0.60	1.32	0.34	2.07	0.53	1.53	0.87	0.83	0.69	4.70	0.70
SO_4^{2-}(mg/L)	57.17	03.05	16.00	123.13	14.00	51.50	18.67	43.00	14.0	35.67	13.10
PO_4^{2-} (mg/L)	1.86	6.99	11.83	10.86	12.42	5.87	10.69	1.65	8.27	13.37	7.00
F^- (mg/L)	3.28	6.50	1.17	5.18	0.83	3.18	2.12	1.57	1.00	2.38	2.37
Ca (mg/L)	16.23	8.18	4.43	5.78	1.82	12.56	3.17	14.49	3.40	5.42	3.17
Mg (mg/L)	10.54	15.177	9.31	8.22	13.93	10.91	15.22	9.75	8.60	13.37	15.21
NO_3^- (mg/L)	3.12	5.08	5.82	4.75	9.28	16.85	9.90	8.82	9.82	34.78	9.27

The analysis of the physicochemical parameters of hand-dug well water in Kauru LGA reveals a mixed water quality status across the 11 wards. Physical parameters such as pH (6.72–7.79) and Electrical Conductivity (EC) (136–905.67 µS/cm) generally fall within WHO acceptable limits of 6.5–8.5 and ≤1000 µS/cm, respectively. However, several chemical parameters exceed permissible thresholds, indicating potential health risks.

Nitrate (NO_3^-) levels range from 3.12 mg/L to 34.78 mg/L, significantly surpassing the WHO limit of 10 mg/L in wards such as MAK (34.78 mg/L) and K1 (16.85 mg/L). Elevated nitrate levels are of concern due to the risk of methemoglobinemia, especially in infants. Similarly, phosphate (PO_4^{2-}) levels are high in multiple wards (6.99–13.37 mg/L), exceeding the acceptable 1 mg/L limit, which can contribute to eutrophication. Sulphate (SO_4^{2-}) concentrations, though varied, exceed 100 mg/L in some samples, leading to potential gastrointestinal disturbances.

Turbidity levels (0.69–53.74 NTU) also exceed the WHO guideline of ≤5 NTU in several locations, particularly MAK (53.74 NTU), indicating possible microbial contamination or suspended solids. High turbidity not only affects aesthetics but also compromises disinfection processes. Total Hardness (54.67–334 mg/L) varies significantly, with samples from Bad Sam (334 mg/L) exceeding the moderately hard water threshold, leading to potential scaling in water systems.

These contaminations are likely due to anthropogenic activities such as agricultural runoff, inadequate waste management, and poor sanitation practices.

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Table 3.0:Kauru Local Government Area Water Quality Status

S/N	Ward	WQI	Comment/Remark
1.	BadurumSama	128.9494	>100, unsuitable
2.	Bital	307.4463	>100, unsuitable
3.	Damakasuwa	95.1692	>75 and < 100, very poor
4.	Dawaki	240.6002	>100, unsuitable
5.	Geshere	101.3609	>100, unsuitable
6.	Kamaru	147.7700	>100, unsuitable
7.	Kauru East	103.3088	>100, unsuitable
8.	Kauru West	87.8979	> 75 and <100, very poor
9.	Kwassam	172.0015	>100, unsuitable
10.	Makami	294.2967	>100, unsuitable
11.	Pari	105.8247	> 75 and <100, very poor

Table 3.0 presents the Water Quality Index (WQI) and corresponding remarks for 11 wards in Kauru LGA. The overall water quality index (WQI) suggests that the wells are unfit for direct consumption without treatment. These high WQI values highlight that the majority of the water samples are unsuitable for human consumption, with scores exceeding 100, particularly in Bital (307.4463), Makami (294.2967) and Dawaki (240.6002). These high WQI values align with previously analyzed physicochemical parameters, such as elevated nitrate, phosphate, sulphate, and fluoride levels, which were well above WHO permissible limits.

IV. RECOMMENDATION

It is recommended that alternative sources of drinkable water be provided to the affected communities. Additionally, existing well water should undergo proper treatment to meet WHO standards. Regular monitoring of water quality, public awareness campaigns on safe water use, and improved waste management practices should be implemented to prevent further contamination.

V. CONCLUSION

It is therefore concluded that the water quality of Kauru Local Government Area is generally unsuitable for human consumption, as indicated by the Water Quality Index (WQI) and the high levels of certain physicochemical parameters, including nitrate, sulphate, phosphate, turbidity, and TDS, which exceed WHO limits. These results highlight potential sources of contamination, such as agricultural runoff, poor waste disposal practices, and geological influences.

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