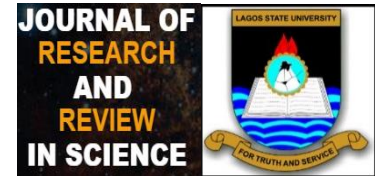


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ORIGINAL RESEARCH



Quality Assessment of Drinking Water in Selected Public Primary Schools in Lagos State.

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Abstract:

Introduction: Access to safe drinking water remains a critical public health concern, particularly in developing countries where inadequate sanitation, poor water treatment, and faecal contamination contribute to the spread of waterborne diseases. In Lagos State, Nigeria, limited access to potable water forces many communities to rely on alternative sources that may be microbiologically unsafe, posing significant health risks, especially to school children.

Aims: This study aimed to assess the physicochemical and bacteriological quality of drinking water in selected public primary schools in Lagos State, Nigeria.

Materials and Methods: Water samples were collected from twenty public primary schools using standard sampling procedures. Physicochemical parameters, including temperature, pH, turbidity, total dissolved solids, residual chlorine and Visual inspection, Colour, Taste, Odour, Iron, Total acidity, Total hardness, Calcium hardness, Magnesium hardness, Chloride, Nitrite, Nitrate, Organic matter, and Salinity, were analysed using standard laboratory methods. Bacteriological quality was determined using the pour plate method for total plate count and the Most Probable Number (MPN) technique for coliform detection. Isolates were further identified based on morphological and biochemical characteristics.

Results: Most physicochemical parameters were within acceptable limits; however, pH values were generally acidic, and several samples showed elevated total dissolved solids. Residual chlorine was absent in all samples, indicating inadequate disinfection. Bacteriological analysis revealed that the majority of samples exceeded recommended limits, with 85% testing positive for coliforms. Identified organisms included *Escherichia coli*, *Klebsiella*, *Enterobacter*, and *Citrobacter* species, indicating faecal contamination.

Conclusion: Despite acceptable physicochemical properties, the presence of high microbial loads renders the water unsafe for consumption. The findings highlight the need for improved water treatment, regular monitoring, and better sanitation practices in public primary schools to reduce the risk of waterborne diseases.

To Keywords: Water, Coliforms, Physicochemical, Contamination.

All co-authors agreed to have their names listed as authors.

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1. INTRODUCTION

Safe drinking water for human consumption should be free from pathogens such as bacteria, viruses, and protozoan parasites, meet standard guidelines for taste, odour, appearance, and chemical composition, and be available in adequate quantities for domestic use (Sharma and Bhattacharya, 2017). However, inadequate sanitation and persistent faecal contamination of water sources have resulted in a significant proportion of people in both developed and developing countries lacking access to microbiologically safe drinking water, leading to widespread diarrhoeal diseases (Malgwi *et al.*, 2023). Drinking water remains one of the most important sources of gastroenteric diseases globally, largely due to faecally contaminated raw water, failures in treatment processes, and recontamination during distribution (Edessa *et al.*, 2017).

Globally, a large proportion of drinking water is sourced from surface waters, which are highly susceptible to microbial contamination from sewage discharge, faecal matter from domestic and wild animals, and environmental factors (Sasakova *et al.*, 2018). Water is an essential natural resource vital for the survival of all living organisms, yet its declining quality and availability have become major public health concerns, particularly in Africa and Nigeria (Rose *et al.*, 2025). Water scarcity not only contributes to disease outbreaks but also results in significant economic losses (Ringler *et al.*, 2022).

The quality of drinking water continues to deteriorate due to inadequate treatment facilities, direct discharge of untreated sewage into water bodies, and inefficient management of pipe-borne distribution systems (Isukuru *et al.*, 2024). In developing countries such as Nigeria, especially within the Lagos metropolis where potable water scarcity is pronounced, many communities rely on alternative sources such as rivers, streams, and boreholes, which are often unsafe for domestic use (Olabode and Comte, 2024). Access to safe drinking water in Lagos State remains limited and uneven, with less than 60% of residents having access to potable water and only about 8.9% accessing safely managed supplies. Consequently, many households depend on groundwater sources and sachet water, as public piped supply serves only about 30–34% of the population (Obani, 2020). The consumption of unsafe water, particularly when contaminated with microorganisms, contributes to disease burden and mortality, with adverse effects on public health and the economy. Additional risks arise from lapses in treatment processes, contamination during distribution, and handling practices at the point of use (Rath, 2021; Abkar *et al.*, 2024).

Lack of access to clean water in developing countries has been linked to approximately 1.87 million deaths of children annually due to diarrhoea (Choi *et al.*, 2025). Primary school children are especially vulnerable to waterborne infections, and public schools often lack adequate water supply systems and proper hygiene practices, thereby increasing health risks (Bosede *et al.*, 2025). Despite existing studies on water quality in Lagos, there is limited information on the physicochemical and microbiological quality of drinking water in public primary schools, where exposure risk is high. Poor sanitation, inadequate treatment, and possible contamination within distribution systems may further compromise water safety in these settings. There is therefore a need for regular microbiological assessment of drinking water, alongside improved emphasis on both public and household water treatment as recommended by the World Health Organization (Idibie *et al.*, 2018).

Therefore, this study aims to assess the quality of drinking water in selected public primary schools in Lagos State, Nigeria. Specifically, the objectives are to evaluate the physicochemical properties of the water samples, determine their bacteriological quality using standard methods, and identify potential microbial contaminants associated with faecal pollution.

2. MATERIAL AND METHODS

2.1 Sample Collection

Water samples were collected from 20 different public primary schools in Lagos state, using a clean labelled bottles and sterilized bottles for both physicochemical and bacteriological analysis respectively. Upon collection, the samples were stored in 4°C before analyses.

2.2 Physicochemical Analysis of Water Samples

The temperature was measured using Mercury and Flow Filled Thermometer (Skalenwert 1K 1GL 1996), pH was measured using a pH meter (ETL model 7030 pH meter), conductivity was determined using conductivity meter (model HACHDR 2010), turbidity was measured with a calibrated turbid meter (Partech model DRT 100B), Iron, nitrate and sulphate were determined using POTABLE DATA LOGGING SPECTROPHOTOMETER (HACH DR/2010), residual chlorine, total hardness, total alkalinity, magnesium hardness, calcium hardness, chloride and salinity were determined as described by APHA, (2017).

2.3 Bacteriological Analysis of Water Samples

The bacterial population count of the sample was determined using pour plate method. Briefly, 1 ml of the sample was dispensed into sterile Petri dish, then 12 ml of nutrient agar was poured into the Petri dish and swirled gently for homogenization. The plates were incubated at 37°C for 24 hours after which colonies formed were counted. The counts were determined as cfu/ml.

The sample was also subjected to coliform count using the most probable number (MPN) technique as described by Tillet *et al.*, 1987. This was done by transferring 1 ml of the sample into 5 test-tubes that contained 5 ml of single strength MacConkey broth medium and Durham tubes. The inoculated tubes were incubated at 37°C for 24 - 48 hours. Similarly, 10 ml of the sample was transferred into 5 test-tubes that contained 10 ml of double strength MacConkey broth medium and Durham tubes. The inoculated tubes were incubated at 37°C for 24 - 48 hours. Same dilution was repeated using 50 ml of the sample in 50 ml of double strength MacConkey broth medium. The tubes and bottles were examined for colour change and gas production after incubation. Positive tubes and bottles from the presumptive test were inoculated on brilliant green agar plates and incubated at 37°C for 24 hours and observed for growth. Colonies formed within 24 hours indicated a positive confirmed test. The resulting colonies were sub-cultured into nutrient agar plates and stored in nutrient agar slant. Subsequently, the isolates were characterized and identified based on their colonial, morphological and biochemical characteristics according to the taxonomic schemes of Cowan and Steel (Cowan, 1993).

3. RESULTS AND DISCUSSION

The physicochemical and bacteriological results of water samples collected from twenty public primary schools in Lagos State are presented in Table 1, 2, 3, 4. The results were evaluated using the Nigerian Standard for Drinking Water Quality (NSDWQ) and World Health Organization (WHO) guidelines.

The physical parameters assessed, assessed in this study were largely within acceptable limits (Table 1). The temperature of all samples was consistently recorded at 26°C, which falls within the recommended range (22–30°C). All samples were visually clear, with colour values ranging from 7.5 to 10 Hazen units, complying with the permissible limit of 0–15 Hazen units. These findings are similar to the work of Ray *et al.*, (2016), where it was observed that all water samples complied with the recommended NSDWQ visibility and colour standard.

Turbidity values ranged from 0.00 to 1.6 NTU, well below the maximum acceptable limit of 5 NTU, indicating low levels of suspended particles. Taste and odour were generally unobjectionable across the samples. These findings are similar to the work of Olaleye and Ogunbajo (2015), where it was observed that the groundwater samples in Ikorodu, Lagos complied with the recommended NSDWQ turbidity standard.

However, certain chemical parameters deviated from recommended standards. The pH values ranged from 5.0 to 7.2, with most samples falling below the NSDWQ acceptable range of 6.8–8.5, indicating slightly acidic conditions. These findings align with the work of Arhin *et al.* (2023), where over 90% of the drinking water samples are acidic. Acidic water can enhance the solubility of heavy metals and contribute to pipe corrosion. When consumed, these metals can pose serious health risks, including neurological disorders, kidney damage, gastrointestinal irritation, and developmental problems in children (Briffa *et al.*, 2020). This observation is comparable to the findings of Oria-Usifo *et al.* (2018), who also reported substandard pH values in borehole water samples in Nigeria.

Total dissolved solids (TDS) varied widely, with several samples exceeding the recommended limit of 500 mg/l, reaching values above 900 mg/l in some cases. These finding aligns with the work of Islam *et al.* (2017), where the water samples did not comply with the recommended WHO standard of total dissolved solids present in water.

Residual chlorine was absent in all samples, contrary to the recommended level of 0.3 mg/l, suggesting inadequate or absent disinfection. Residual chlorine is essential for maintaining microbiological safety within distribution systems. Its absence suggests insufficient disinfection and increases the risk of microbial contamination. This finding supports the report by Kulmedev and Achobe (2024), who highlighted that inadequate chlorination contributes significantly to poor microbial water quality in developing countries.

Other chemical parameters such as iron, chloride, sulphate, and total hardness were generally within acceptable limits. Iron concentrations were mostly below the permissible limit of 0.3 mg/l, except for a few isolated cases.

Total hardness values ranged from 52 to 204 mg/l, indicating that the water samples were predominantly soft to moderately hard. Chloride and sulphate concentrations were also within permissible limits, suggesting minimal contamination from these ions. The result of this work aligns with the findings of Negi *et al.* (2025), where it was discovered that most water samples fall within the acceptable water hardness limit of World Health Organization (WHO).

Despite the relatively acceptable physicochemical quality of the water samples, bacteriological analysis revealed significant contamination. The total plate count showed that most of the samples exceeded the WHO guideline value of 100 CFU/ml (Table 2), with several samples recorded as too numerous to count (TNTC). This suggests a high microbial load and poor sanitary conditions. Similar findings were reported by Ogunware *et al.* (2020), where water samples from unprotected well was bacteriological assessed in some selected areas in Lagos state, where some of the water samples total plate count were recorded as too numerous to count (TNTC).

The Most Probable Number (MPN) analysis indicated that 85% of the water samples had coliform counts far exceeding the WHO standard of less than 1 coliform per 100 ml. Only a few samples met the acceptable limit (Table 3). This aligns with the finding of Shariq *et al.* (2016), where most of the water samples had coliform counts that exceeds the WHO standard of <1 coliform per 100 ml (CFU/100 ml).

The cultural and morphological characteristics of the isolates showed that all isolates were Gram-negative, rod-shaped bacteria, consistent with coliform organisms and biochemical characterization using IMViC tests identified the isolates as *Escherichia coli*, *Klebsiella* species, *Enterobacter* species, and *Citrobacter* species (Table 4). The presence of these organisms is indicative of faecal contamination and poses a significant public health risk, particularly the potential transmission of waterborne diseases such as, diarrhoea, typhoid and gastroenteritis.

This finding is similar to the work of Idu *et al.* (2026), where all water samples had coliform that exceeds the WHO acceptable limit of <1 for coliform count and the isolates discovered is same as the result of this research. The high level of microbial contamination observed in this study may be attributed to several factors, which includes, poor sanitation practices, leakage in distribution systems, inadequate water treatment, and possible contamination at the point of use. These factors have been widely documented as major contributors to water quality deterioration in developing countries (Ng'andwe *et al.*, 2025).

Table 1: Physicochemical properties of water samples from selected public primary schools in Lagos State

S/N	PARAMETER	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	NSDWQ
PHYSICAL																						
1	Temp. of water (0°C)	26°C	26°C	26°C	26°C	26°C	26°C	26°C	26°C	26°C	26°C	26°C	26°C	26°C	26°C	26°C	26°C	26°C	26°C	26°C	26°C	22-30
2	Temp. of air (0°C)	30°C	30°C	30°C	30°C	30°C	30°C	30°C	30°C	30°C	30°C	30°C	30°C	30°C	30°C	30°C	30°C	30°C	30°C	30°C	30°C	25-30
3	Visual inspection	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	Clear
4	Colour (Hazen)	7.5	10	10	10	10	10	7.5	10	10	7.5	7.5	10	7.5	10	10	10	10	7.5	7.5	10	0-15
5	Taste	U _o	O	O	O	O	O	U _o	O	O	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	Unobjectionable
6	Odour	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	U _o	Unobjectionable
7	Turbidity (NTU)	1.6	1.2	1	1	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5NTU
8	Total dissolve solid mg/l	146	793	923	920	921	924	146	923	922	143	146	919	144	149	189	150	156	152	153	924	500
CHEMICAL																						
9	pH	5.0	6.8	7.0	6.9	7.2	6.9	5.1	6.4	7.2	5.4	5.2	7.0	6.0	5.2	5.4	5.2	5.4	5.3	5.1	5.4	6.8-8.5
10	Residual chlorine mg/l	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.3
11	Iron (mg/l)	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.8	0.1	0.3
12	Total Alkalinity (mg/l)	4	4.8	7	7	8	7	4	4.6	8	4	4	7	4	4.1	4.2	4.3	4.4	4	4.6	4.7	No guideline value
13	Total Hardness (mg/l)	52	188	194	188	192	199	72	204	196	53	76	190	68	64	66	60	69	67	62	192	400
14	Ca. Hardness (mg/l)	37	109	120	107	162	101	49	160	120	37	40	100	49	44	46	49	50	52	56	113	200
15	Mg Hardness (mg/l)	15	79	74	81	30	98	23	44	76	16	36	90	19	20	20	29	19	13	10	79	50
16	Free CO ₂ (mg/l)	27	12	0.88	0.88	0.79	0.88	27	20	0.79	27	26	0.88	22	27	28	27	26	27	27	25	No guideline value
17	Chloride (mg/l)	24	42	47	41	40	42	21	43	45	19	10.29	9.99	10.89	9.98	8.99	10.29	10.27	9.99	8.89	60	250
18	Nitrate (mg/l)	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
19	KMNO ₄ (mg/l)	0.14	0.28	0.30	0.27	0.22	0.18	0.22	0.21	0.19	0.19	0.18	0.14	0.22	0.11	0.19	0.20	0.22	0.30	0.17	0.26	0.0-3.0
20	Sulphate SO ₄ (mg/l)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	100

Table 2: Total plate count of water samples from selected public primary schools in Lagos state

Samples code	CFU/ml	WHO
A	TNTC	100
B	110	100
C	16	100
D	TNTC	100
E	TNTC	100
F	TNTC	100
G	50	100
H	110	100
I	20	100
J	86	100
K	91	100
L	116	100
M	TNTC	100
N	110	100
O	TNTC	100
P	106	100
Q	105	100
R	TNTC	100
S	40	100
T	50	100

TNTC- Too Numerous To Count

Table 3: Coliform counts of water samples from selected public primary schools in Lagos State

Samples	Double strength 50ml (1 Bottle)	Double strength 10ml (5 Test Tubes)	Single strength 5ml (5 Test Tubes)	MPN per 100ml	WHO Standard
A	1	3	3	18	<1
B	1	3	3	18	<1
C	1	1	5	<1	<1
D	1	5	1	35	<1
E	1	4	2	22	<1
F	1	4	2	22	<1
G	0	0	0	<1	<1
H	1	4	2	22	<1
I	1	5	5	>180	<1
J	1	4	2	>180	<1
K	1	5	5	<1	<1
L	1	5	5	43	<1
M	0	0	0	>180	<1
N	1	4	5	43	<1
O	1	5	5	>180	<1
P	1	4	5	43	<1
Q	1	3	5		<1
R	1	2	3	12	<1
S	1	5	4	161	<1
T	0	0	0	<1	<1

MPN; Most Probable Number obtained from Tillet *et al.* (1987).

Table 4: Cultural, morphological and biochemical characterization of isolates.

Sam ples	Gram staining Reaction	Shape	Motility Test	Indole Test	Urease Test	Methyl Red Test	Voges Proskauer Test	Citrate Test	Likely Organisms
A	-	Rod	+	+	-	+	-	-	<i>Escherichia coli</i>
B	-	Rod	-	-	+	-	+	+	<i>Klebsiella species/ Enterobacter species</i>
C	-	Rod	+	+	-	+	-	-	<i>Escherichia coli</i>
D	-	Rod	+	+	+	+	+	+	<i>Citrobacter</i>
E	-	Rod	-	-	-	+	-	-	<i>Escherichia coli</i>
F	-	Rod	+	-	+	+	-	+	<i>Citrobacter</i>
H	-	Rod	+	-	+	+	-	+	<i>Citrobacter</i>
I	-	Rod	-	-	+	-	+	+	<i>Klebsiella species/ Enterobacter species</i>
K	-	Rod	+	+	-	+	-	-	<i>Escherichia coli</i>
L	-	Rod	+	-	+	+	-	+	<i>Citrobacter</i>
N	-	Rod	+	+	-	+	-	-	<i>Escherichia coli</i>
O	-	Rod	-	-	+	-	+	+	<i>Klebsiella species/ Enterobacter species</i>
P	-	Rod	+	+	-	+	-	-	<i>Escherichia coli</i>
Q	-	Rod	+	-	+	+	-	+	<i>Citrobacter</i>
R	-	Rod	+	+	+	+	+	+	<i>Citrobacter</i>
S	-	Rod	+	-	+	+	+	+	<i>Escherichia coli</i>

Cowan and Steels manual for Identification of Medicinal Bacteria was used as a guide for the identification of the organisms

4. Conclusion

The results of this study indicate that 17 out of the 20 water samples are unfit for consumption due to the presence of coliform bacteria, which pose significant public health risks. The detection of these organisms suggests faecal contamination and highlights the potential for waterborne diseases among school children. Proper construction and siting of water supply systems are essential to prevent contamination of tap water sources. In addition, controlling human activities such as improper sewage disposal and waste management is critical in reducing microbial contamination. Factors such as leakage in distribution pipes, exposure of storage reservoirs, and surface runoff have been identified as major pathways for contamination and must be effectively managed. Therefore, adequate attention should be given to the design, maintenance, and monitoring of water supply systems in public primary schools to ensure the provision of safe and potable drinking water.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

Adams Adewale: Conceptualisation, Study design, Field and Lab investigation and supervision, Draft of manuscript; Sewanu Akapo: Field and Lab investigation, Editing of manuscript; Helen Ali: Review of manuscript

CONSENT

Informed consent was obtained from the selected hospitals for the study

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