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ORIGINAL RESEARCH

Quality Assessment of Drinking Water in Hospitals in Lagos State, Nigeria.

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Abstract:

Introduction: Access to safe drinking water is essential for human health, yet water quality remains a major public health concern, particularly in developing countries experiencing rapid urbanisation and environmental stress. In healthcare settings, contaminated water poses an even greater risk due to the vulnerability of patients to waterborne infections. However, there is limited information on the quality of hospital drinking water in Lagos State, Nigeria. This study therefore assessed the physicochemical and bacteriological quality of drinking water in selected hospitals in Lagos State.

Aims: To determine the physicochemical properties, total plate count, coliform count, and identify isolated coliform bacteria from water samples in hospitals in Lagos State.

Materials and Methods: Water samples were collected from 20 hospitals in Lagos State using sterile and labelled bottles and transported under cold conditions (4°C) prior to analysis. Physicochemical parameters including Temperature, Visual inspection, Colour, Taste, Odour, pH, Conductivity, Turbidity, Total dissolved solids, Residual chlorine, Iron, Total acidity, Total hardness, Calcium hardness, Magnesium hardness, Chloride, Nitrite, Nitrate, Organic matter, and Salinity were determined using standard laboratory methods. Bacteriological analysis was carried out using the pour plate technique for total plate count and the most probable number (MPN) method for coliform count. Isolates were further identified based on morphological and biochemical characteristics.

Results: All samples had pH values ranging from 5.4 to 6.2, below recommended standards, indicating acidity. Most physicochemical parameters were within acceptable limits, except total dissolved solids, where 5 samples exceeded the standard. Microbiological analysis showed that 12 (60%) samples exceeded the WHO limit for total plate count, with 8 samples recorded as too numerous to count. Additionally, 15 samples contained coliforms above acceptable limits, including *Escherichia coli*, *Klebsiella* species, *Proteus vulgaris*, *Enterobacter* species, and *Citrobacter* species, indicating faecal contamination.

Conclusion: The study reveals that most hospital drinking water samples were microbiologically unsafe and acidic, posing potential health risks. Regular monitoring, improved treatment, and strict water safety practices are recommended to ensure a safe water supply in healthcare facilities.

Keywords: Water, Contamination, Coliforms, Physicochemical, Hospital, organic matter, *Escherichia coli*

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

1. INTRODUCTION

The importance of environmental quality, particularly water quality assessment and treatment, cannot be overemphasised due to its significant impact on human health and the economic well-being of populations [1]. Safe drinking water is essential for life, as it supports vital physiological processes and overall well-being. However, the quality of drinking water remains a major public health concern globally, especially in developing countries where rapid population growth, urbanisation, and anthropogenic activities continue to exert pressure on available water resources [2]. Consequently, effective monitoring and comprehensive assessment of drinking water systems are important for preventing waterborne diseases and ensuring public safety [3].

In Nigeria, access to safe and reliable drinking water is still a significant challenge. A large proportion of the population lacks access to improved water sources and adequate sanitation facilities, with many depending on alternative sources such as boreholes, wells, and water vendors ([4,5]. Even where improved sources exist, water quality is not always guaranteed due to poor infrastructure, inadequate maintenance, and environmental contamination [6]. This situation calls for concern in areas characterised by high population density, rapid urbanisation, and intense human activities, where the risk of water contamination is significantly high, and Lagos State, which is the location of the study, is a perfect example.

In hospital environments, the quality of drinking water is of critical importance because patients, especially those who are immunocompromised, are highly susceptible to infections. Contaminated water in healthcare settings can serve as a source of healthcare-associated infections, thereby undermining patient safety and treatment outcomes [7]. Despite this risk, water quality in many hospitals is often inadequately monitored, and contamination within distribution systems may go undetected. Preventive strategies such as water safety plans are therefore essential to ensure the consistent supply of safe water in healthcare facilities [8].

However, there is limited documented evidence on the physicochemical and microbiological quality of drinking water in hospitals within Lagos state. This lack of data creates a gap in understanding the potential health risks associated with water use in these settings. Therefore, this study aims to assess the physicochemical and bacteriological quality of drinking water in selected hospitals in Lagos state, Nigeria.

2. MATERIAL AND METHODS

2.1 Sample Collection

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

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 DATALODGING 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 [9]. 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 [10].

3. RESULTS AND DISCUSSION

The physicochemical and bacteriological characteristics of drinking water samples collected from twenty hospitals in Lagos State are presented in Tables 1, 2, 3, and 4. The results were evaluated using the Nigerian Standard for Drinking Water Quality (NSDWQ) and World Health Organisation (WHO) guidelines.

The physicochemical results showed that all the 20 samples had pH values ranging from 5.4 to 6.2, which fall below the Nigerian Standard for Drinking Water Quality (NSDWQ) of 6.8-8.5. This implies that the water samples are acidic and not safe for drinking. These findings align with the work of [11], where over 90% of the drinking water samples tested were acidic. Acidic water can enhance the solubility of heavy metals and contribute to pipe corrosion, which when consumed, can cause irritation and ingestion of toxic metals which are detrimental to the health of consumers [12].
All the water samples had temperature, appearance, colour, turbidity and conductivity within the accepted range of the NSDWQ. The exception to this trend was the result of total dissolved solids, in which 5 (B, D, E, J and Q) out of the 20 samples were found to be above the NSDWQ standard of 500mg/l with values ranging from 505-712 mg/l, as shown in **Table 1**. Although the majority of the physicochemical parameters were within specified limits, there was considerable variation among values recorded among samples from the different hospitals. For instance, total hardness values ranged from 22-220mg/L while the mean value was 63.45mg/L with a standard deviation of 53.28. The same observation was made with calcium hardness and magnesium hardness, with standard deviations of 31.5 and 22.38, respectively. There was less variability in values of parameters such as free CO_2, with a mean and standard deviation of 17.65 and 1.69, respectively.

The total plate count of the water samples showed that 12 (60%) samples out of the 20 samples exceeded the limit set by World Health Organization (WHO) of 100 CFU/ml, and 8 out of the 20 samples tested (B,E,F,G,H, K,O and Q) had colonies that were Too Numerous To Count (TNTC). Therefore, it exceeded the limit of 100 CFU/ml, which was set by the World Health Organisation (WHO) for human consumption of drinking water. This result is shown in **Table 2**. This finding is similar to the work of Udoh [13], where it was discovered that the water samples tested had colonies that were too numerous to count. This shows a high level of contamination, and the water is unfit for human consumption.

The total coliform count results showed that 15 out of the 20 water samples contained coliforms that is above the acceptable standard of the WHO of <1 as shown in **Table 3**. The coliform bacteria present in the water samples are *Escherichia coli*, *Klebsiella* species, *Proteus vulgaris*, *Enterobacter* species, and *Citrobacter* species. The identification of these organisms was based on their reaction to the IMVIC tests as shown in **Table 4**. The presence of coliform that exceeds the WHO standard indicates faecal contamination and a high risk of waterborne diseases, rendering the water unsafe for consumption [14]. Coliforms, particularly faecal coliforms such as *Escherichia coli*, originate from the intestinal tracts of humans and warm-blooded animals; their detection suggests that pathogenic microorganisms may also be present. *Escherichia coli* is widely recognised as an indicator of faecal contamination. While some strains are harmless, pathogenic strains (e.g., enterotoxigenic and enterohemorrhagic types) can cause gastrointestinal infections, leading to diarrhoea, abdominal cramps, vomiting, and in severe cases, haemolytic uremic syndrome [15]. Its presence in water strongly suggests contamination with faecal matter and the possible presence of other pathogens. *Klebsiella* species are opportunistic pathogens commonly associated with respiratory tract infections, urinary tract infections (UTIs), septicaemia, and wound infections. They are of great concern in healthcare settings due to their ability to develop antibiotic resistance and cause healthcare-associated infections [16]. *Proteus vulgaris* is known for causing urinary tract infections and wound infections. It produces urease, which can lead to the formation of kidney stones and complications in the urinary tract [17]. It may also cause septicaemia in severe cases.

Enterobacter species are opportunistic pathogens that can cause infections such as UTIs, respiratory infections, bacteraemia, and neonatal sepsis. They are commonly implicated in hospital-acquired infections and are known for their resistance to multiple antibiotics [18]

Table 2: Total plate count of water samples from hospitals in Lagos State

Samples	CFU/ml	WHO standard
A	56	100
B	TNTC	100
C	23	100
D	30	100
E	TNTC	100
F	TNTC	100
G	TNTC	100
H	TNTC	100
I	50	100
J	124	100
K	TNTC	100
L	51	100
M	125	100
N	51	100
O	TNTC	100
P	112	100
Q	TNTC	100
R	4	100
S	85	100
T	101	100

TNTC- Too Numerous To Count

Table 1: Physicochemical properties of water samples from hospitals 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
1	Temp. of water (°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 (°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)	5	10	10	10	10	10	7.5	7.5	5	2.5	7.5	10	5	7.5	10	2.5	10	10	7.5	5	0-15
5	Taste	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
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)	0.00	0.63	0.94	0.73	1	0.00	0.00	0.87	0.91	0.00	0.00	0.00	0.83	0.41	0.82	0.00	1	1	1.8	1.4	5NTU
8	Total dissolve solid mg/L	134	584	466	672	712	112	133	342	329	607	168	111	223	334	304	8	505	360	499	377	500 (max)
9	pH	6.0	5.8	5.8	6.0	6.2	5.9	5.6	5.5	5.5	5.4	6.0	5.8	5.8	6.0	5.9	5.8	5.6	5.5	5.6	5.6	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)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.3
12	Total Acidity	16	20	20	18	16	20	20	22	22	22	18	20	20	18	20	20	20	20	21	20	No guideline value
13	Total Hardness (mg/L)	43	99	73	201	220	45	40	58	54	22	38	39	40	28	40	22	48	50	62	47	400
14	Ca. Hardness (mg/L)	32	71	47	114	138	28	27	31	41	17	21	26	30	21	36	17	29	33	47	32	200
15	Mg Hardness (mg/L)	11	28	26	87	82	17	13	27	13	5	17	13	10	17	4	5	19	17	15	15	50
16	Free CO_2 (mg/L)	14	18	18	16	14	18	18	20	20	20	16	18	18	16	18	18	18	18	19	18	No guideline value
17	Chloride (mg/L)	4	29	20	65	89	4	5	8	9	3	4	3	3.4	4	3.8	2	39	18	40	8	250
18	Nitrate (mg/L)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
19	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

Citrobacter species are also associated with urinary tract infections, respiratory infections, and septicaemia. In neonates and immunocompromised individuals, they can cause serious conditions such as meningitis and brain abscesses [19]. This raises serious public health concerns, as contaminated water can serve as a vehicle for the transmission of waterborne diseases such as cholera, typhoid fever, dysentery, and gastroenteritis.

Possible points of contamination may include leakages in pipes, cross-contamination with sewage systems, poor sanitation practices within the hospital environment, and contamination within storage tanks or plumbing systems, where bacteria can enter and proliferate [20]. This finding is similar to the work of [21], where coliform bacteria in drinking water sources in Malang city was analysed and it was discovered that all the samples had coliform counts that exceeded the WHO standard of <1MPN/100 ml.

Table 3: Coliform count of water samples from hospitals in Lagos State

Samples	Double strength (1 Bottle)	Double strength 10ml (5 Tubes)	Single strength 5ml (5 Tubes)	MPN per 100ml	WHO standard
A	0	0	0	<1	<1
B	1	3	3	18	<1
C	1	3	3	18	<1
D	0	0	0	<1	<1
E	1	3	3	18	<1
F	1	4	0	<1	<1
G	0	0	0	<1	<1
H	1	3	4	21	<1
I	0	0	0	<1	<1
J	0	0	0	<1	<1
K	1	5	5	>180	<1
L	1	5	5	>180	<1
M	0	0	0	<1	<1
N	1	3	2	14	<1
O	1	5	5	>180	<1
P	1	4	3	28	<1
Q	1	3	3	18	<1
R	1	1	3	9	<1
S	1	2	2	10	<1
T	1	3	1	11	<1

MPN; Most Probable Number obtained from Tillet *et al*.[9].

Table 4: Cultural, morphological and biochemical characterisation of isolates

Samples	Gram staining reaction	Shape	Motility Test	Indole Test	Urease Test	Methyl Red Test	Voges Proskauer Test	Citrate Test	Likely Organisms
B	-	Rod	+	+	-	+	-	-	*Escherichia coli*
C	-	Rod	-	-	+	-	+	+	*Klebsiella* species/ *Enterobacter* species
D	-	Rod	+	+	+	+	+	+	*Citrobacter*
E	-	Rod	+	+	+	+	-	-	*Proteus vulgaris*
F	-	Rod	-	-	-	+	-	-	*Escherichia coli*
H	-	Rod	+	-	+	+	-	+	*Citrobacter*
K	-	Rod	-	-	+	-	+	+	*Klebsiella* species/ *Enterobacter* species
L	-	Rod	-	-	-	+	-	-	*Escherichia coli*
N	-	Rod	+	+	-	+	-	-	*Escherichia coli*
O	-	Rod	+	-	+	+	-	+	*Citrobacter*
P	-	Rod	+	+	-	+	-	-	*Escherichia coli*
Q	-	Rod	-	-	+	-	+	+	*Klebsiella* species/ *Enterobacter* species
R	-	Rod	+	+	-	+	-	-	*Escherichia coli*
S	-	Rod	+	-	+	+	-	+	*Citrobacter*
T	-	Rod	+	-	+	+	+	+	*Escherichia coli*

Cowan and Steels [10] manual for Identification of Medicinal Bacteria was used as a guide for the identification of the organisms

4. Conclusion

The findings of this study show that many of the water samples from hospitals in Lagos State did not meet the required safety standards for drinking water quality. The heavy load of coliform bacteria such as *Escherichia coli*, *Klebsiella* species, *Proteus vulgaris*, *Enterobacter* species, and *Citrobacte*r species indicates faecal contamination and suggests poor water treatment and supply systems. This is a serious public health concern because contaminated water in hospitals can increase the risk of infections among patients who are already vulnerable and immunocompromised. There is therefore a need for regular monitoring, improved water treatment methods, proper maintenance of water facilities, and stricter enforcement of safety standards to ensure that hospitals provide clean and safe drinking water.

COMPETING INTERESTS

Authors have declared that no competing interest exists.

AUTHORS' CONTRIBUTIONS

Adams Adewale: Conceptualization, Study design, Field and Lab investigation and supervision, Draft of manuscript; Sewanu Akapo: Field and Lab investigation, Editing of manuscript: Olabimpe Egberongbe: Manuscript Review; Akeeb Oyefolu: Manuscript Review

CONSENT

Informed consent was obtained from the selected hospitals for the study.

ETHICAL APPROVAL

Not applicable

REFERENCES

1. Yan J, Cui S. Water quality and residents' health: a survey by the self-assessed health method. *Frontiers in Public Health*. 2025:13:1520354.
2. Biswas A, Sarkar S, Das S, Dutta S, Choudhury MR, Giri A, Bera B, Bag K, Mukherjee B, Banerjee K, Gupta D. Water scarcity: A global hindrance to sustainable development and agricultural production–A critical review of the impacts and adaptation strategies. *Cambridge Prisms: Water*. 2025;3:e4. doi.org/10.1017/wat.2024.16
3. Ali QA, Ghareeb OA. Drinking water quality and its impact on public health. *Academia Repository*. 2023 Sep 11;4(9):48-64.
4. Bisi-Johnson MA, Adediran KO, Akinola SA, Popoola EO, Okoh AI. Comparative physicochemical and microbiological qualities of source and stored household waters in some selected communities in southwestern Nigeria. *Sustainability*. 2017;9(3):454.
5. Chukwu HO, Azuh D, Oladosun M. Lack of access to clean water and its effects on health status of residents in border communities of Ogun State, Nigeria. *Sustainable Environment*. 2026;12(1):2615497.
6. Anam BE, Ironbar VE, Unimna FA, Bisong DB, Uzoh EE, Enendem EE, Adie JJ, Ndum VE, Nwugo-Achakpokri ME, Bassey AE, Okorn FT. Achieving sustainable development goal 6 through improved access to clean water and sanitation in Nigerian rural areas. *Journal of Infrastructure, Policy and Development.* 2024;8(8):4225.
7. Weinbren M, Meda M, Hopman J, Fucini G, Sunder W. Defining water safety in healthcare premises. *Journal of Hospital Infection*. 2025;162: 301-9.
8. Krause S, Joel E, Schaum C, Bäumer J, Rücker N, Wienand I, Sturm C, Jahn-Mühl B, Geiger M, Fekete A, van der Heijden S. Water safety planning for healthcare facilities for extreme events. *Journal of Water and Health*. 2024;22(1):77-96.
9. Tillett HE. Most probable numbers of organisms: revised tables for the multiple tube method. *Epidemiology & Infection*. 1987;99(2): 471-6.

10. Cowan, ST, Steel, KJ Cowan and Steel's Manual for Identification of Medical Bacteria. 3rd Edition, Cambridge University Press, 1993 199-241.

11. Arhin E, Osei JD, Anima PA, Afari PD, Yevugah LL. The pH of drinking water and its human health implications: a Case of surrounding communities in the Dormaa Central Municipality of Ghana. *Journal of Health Care Treatment Development*. 2023;4(1): 15-26.

12. Pan L, Li G, Li J, Gao J, Liu Q, Shi B. Heavy metal enrichment in drinking water pipe scales and speciation change with water parameters. *Science of The Total Environment*. 2022;806: 150549.

13. Udoh A, Lawal BK, Akpan M, Labaran KS, Ndem E, Ohabunwa U, Tikare O, Ibrahim UI, Amorha K, Kpokiri E. Microbial contamination of packaged drinking water in Nigeria. *Tropical Medicine & International Health*. 2021;26(11): 1378-400.

14. Odonkor ST, Mahami T. Escherichia coli as a tool for disease risk assessment of drinking water sources. *International Journal of Microbiology*. 2020;2020(1): 2534130.

15. Mueller M, Tainter CR. Escherichia coli Infection. Treasure Island (FL): *StatPearls Publishing*. 2024. https://www.ncbi.nlm.nih.gov/books/NBK564298/

16. Asokan S, Jacob T, Jacob J, AlSosowaa AA, Cherian T, Peijnenburg WJ, Vijayan S. Klebsiella pneumoniae: A growing threat in the era of antimicrobial resistance. *The Microbe*. 2025;7: 100333.

17. Muhsal LK, Theis L, Overmann J, Hamprecht A. Proteus spp.—taxonomy, clinical significance, and antibiotic resistance of a highly versatile pathogen. *Clinical Microbiology Reviews*. 2025;38(4): e00181-24.

18. Salimiyan Rizi K, Ghazvini K, Farsiani H. Clinical and pathogenesis overview of Enterobacter infections. *Reviews in Clinical Medicine*. 2020;6(4): 146-54.

19. Jabeen I, Islam S, Hassan AI, Tasnim Z, Shuvo SR. A brief insight into Citrobacter species-a growing threat to public health. *Frontiers in Antibiotics*. 2023;2: 1276982.

20. Mohammed JN, Swalaha FM. Sewage intrusion into drinking water distribution systems: implications for water resource management. *Environmental Monitoring and Assessment*. 2025;197(10): 1150.

21. Syamsussabri M, Ningtyas RN, Najah AA, Fahmi MS, Suarsini E. Analysis of Coliform Bacteria Contamination in Drinking Water Sources in Malang City. El-Hayah: *Jurnal Biologi*. 2018;7(1): 28-35.