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Isolation and identification of coliforms from public water supplies in Lagos state, Nigeria

Taiwo Bakare-Abidola [1,*], Jelil Olaoye [2] and Adewole Oladapo Adams [3]

[1] *Department of Environmental Science, Georgia Southern University, Georgia, USA.*
[2] *Department of Applied Physical Science, Environmental Science Concentration, Georgia Southern University, Georgia, USA.*
[3] *Department of Microbiology, Faculty of Science, Lagos State University, Nigeria.*

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Abstract

Access to safe drinking water is essential for public health, yet contamination of water sources remains a significant concern, particularly in developing regions. This study aimed to assess the bacteriological quality of water from four major water treatment plants in Lagos State—Adiyan, Iju, Ijanikin, and Ikeja—by isolating and identifying coliform bacteria in both raw and treated water samples. Water samples were collected in sterile glass bottles and analyzed for pH, residual chlorine, total bacterial count, and coliform presence using the Most Probable Number (MPN) method, Gram staining, and biochemical tests, including the Analytical Profile Index (API). The results revealed no residual chlorine (0.0 mg/L) in all treated water samples, indicating a lack of continuous disinfection. pH values ranged from 6.7 to 7.1, falling within WHO standards (6.5–8.5). Total bacterial counts (TBC) in raw water were highest in Iju (27 CFU/mL) and lowest in Ikeja (16 CFU/mL), while treated water showed reductions, with Iju at 11 CFU/mL and Ikeja at 3 CFU/mL. Coliform counts in raw water ranged from 8 to 14 MPN/100mL, while treated water ranged from 4 to 11 MPN/100mL, exceeding the WHO limit of zero coliforms per 100mL. Klebsiella pneumoniae, Escherichia coli, and Pantoea spp. were identified in both raw and treated samples, with E. coli detected in Ikeja raw water, confirming fecal contamination. The persistence of coliforms in treated water suggests treatment inefficiencies, pipeline contamination, or bacterial regrowth within the distribution system. These findings underscore the urgent need for improved chlorine dosing, pipeline maintenance, routine microbial monitoring, and alternative disinfection methods to ensure the microbiological safety of Lagos public water supplies.

Keywords: Water quality; Coliform bacteria; *Escherichia coli*; Bacteriological analysis; Public water supply; Water treatment;

1. Introduction

Water is one of the most vital natural resources essential for the survival of all living organisms, ecological balance, human health, food production, and economic development (WHO, 2022). Access to safe drinking water is a fundamental human right, yet contaminated water remains a major public health risk, particularly in developing countries where waterborne diseases account for high morbidity and mortality rates (UNICEF & WHO, 2023). According to recent estimates, at least 2 billion people globally use contaminated drinking water sources, leading to outbreaks of cholera, typhoid, and diarrheal diseases (World Bank, 2021). The situation is particularly severe in sub-Saharan Africa,

* Corresponding author: Taiwo Bakare-Abidola

where over 70% of households lack access to safely managed drinking water services, exposing millions to microbial contamination and life-threatening illnesses (Adegbite et al., 2021).

Ensuring access to microbiologically safe drinking water is crucial, as water contaminated with human or animal feces presents the highest risk for microbial infections. Pathogens such as *Escherichia coli*, *Salmonella spp.*, *Vibrio cholerae*, and *Shigella spp.* are known to cause severe gastrointestinal infections and have been linked to poor sanitation and inadequate water treatment (Singh et al., 2020). Contamination pathways include wastewater discharge, agricultural runoff, and seepage from poorly maintained sewage systems, all of which introduce fecal microorganisms into surface and underground water sources (Kumpel & Nelson, 2016). The most vulnerable populations—children under five years old, immunocompromised individuals, and those living in high-density urban slums—are disproportionately affected by unsafe drinking water (Afolabi et al., 2019).

To assess water safety, coliform bacteria are widely used as microbiological indicators of contamination. Coliforms, particularly fecal coliforms like *E. coli*, serve as early warning markers of possible pathogen presence in drinking water (Ashbolt, 2015). These bacteria belong to the Enterobacteriaceae family, are gram-negative, facultatively anaerobic, non-spore-forming rods, and can ferment lactose with acid and gas production at 35–37°C within 48 hours. The presence of coliforms, particularly thermotolerant fecal coliforms, suggests recent fecal pollution, making them critical indicators in drinking water quality monitoring (WHO, 2017). Global drinking water standards, such as those from the World Health Organization (WHO) and the United States Environmental Protection Agency (USEPA), require that drinking water must be completely free of *E. coli* and other coliforms per 100mL sample (USEPA, 2023; WHO, 2022). However, studies have reported frequent violations of these standards in many developing regions due to poorly maintained treatment plants, intermittent water supply, and distribution system contamination (Olanrewaju et al., 2022).

Lagos State, Nigeria, with a population exceeding 20 million people, faces severe challenges in water supply management. The Lagos State Water Corporation (LSWC), responsible for public water distribution, operates several major water treatment plants, including Adiyan, Iju, and Isashi, which primarily rely on surface water sources. Additionally, mini waterworks and boreholes serve as alternative sources, especially in urban communities where tap water is unavailable or deemed unsafe (Akinyemi et al., 2023). Despite efforts to provide safe drinking water, studies have consistently shown bacterial contamination in Lagos public water supplies. Aging infrastructure, non-functional chlorinators, and cross-contamination due to leaking pipelines have been identified as major contributing factors to microbial regrowth and post-treatment contamination (Ojo et al., 2021). Furthermore, over 60% of Lagos residents rely on unregulated alternative water sources, such as sachet water, boreholes, and untreated surface water, increasing their risk of exposure to waterborne pathogens (Adepoju et al., 2020).

Past research in Lagos State and other parts of Nigeria has detected coliform bacteria in treated municipal water supplies, raising concerns about the effectiveness of treatment processes. In some cases, treated water still contained *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *E. coli*, indicating either incomplete disinfection or recontamination during distribution (Olanrewaju et al., 2022). The absence of residual chlorine in public water supplies further exacerbates microbial survival, allowing bacteria to persist within pipes, storage tanks, and distribution networks (Singh et al., 2020). Studies have also shown that biofilms within aging pipelines create a conducive environment for bacterial growth, making it difficult to maintain microbial water quality even after treatment (Adegbite et al., 2021).

Given the public health implications of consuming contaminated water, this study aims to assess the bacteriological quality of water from four major water treatment plants in Lagos State—Adiyan, Iju, Ijanikin, and Ikeja—by isolating and identifying coliform bacteria in both raw and treated water samples. The findings will provide insights into the effectiveness of current water treatment processes, identify potential health risks associated with public water supplies, and recommend strategies for improving microbiological water safety in Lagos State.

1.1. Problem Statement

Some of the water works are in a great risks because of the sedimentation tanks problem in the treatment plants which cannot be drained, sand filters are proned to flooding, non functional chlorinators, non or inadequate dosing of disinfecting chemical and inadequate provision of laboratory facilities lead to water contamination. Polluted water may contain pathogenic bacteria, protozoan, viruses and helminthes which are known to cause serious health hazards in

humans. However, for water to be potable it must be microbiologically safe and in order to achieve this, an approach that will eliminate pathogenic organisms from source water must be ensured.

1.2. Study Objectives

- To determine the pH of the raw and treated water sample s and to determine the residual chlorine of the treated water samples.
- To determines the total bacterial population of raw and treated water samples
- To enumerates the total coliforms count of raw and treated water samples.
- To characterized the isolates of raw and treated water samples.

2. Materials and Method

2.1. Sampling

Water samples were collected from four different water works in different areas which are Iju, Adiyan, Ikeja and Ijanikin located in the city of Lagos State.

2.2. Samples collection collection of raw water samples

Water samples were collected into 1 liter of sterile glass bottles and during collection of the raw water sample, the bottles were brought closer to the tap and lowered with the screw cap so that air would not pass inside. The sample bottles were labelled and transported immediately to the laboratory for bacteriological analysis.

2.3. Collection of treated water sample

Water samples were also collected into 1 liter of sterile glass bottles and during collection of treated water. The tap was opened and allowed to run for about 2 minutes, so as to allow any stagnant impurities in the pipe to flush off. The sterile bottles were filled with the water from the tap and it was immediately screw capped so that air won't pass inside. The sample bottles were labeled and transported immediately to the laboratory for bacteriological analysis.

2.4. Sterilization of Glasswares

Glass bottles, bijou bottles, test-tube, measuring cylinder, beaker, pipettes, conical flask were all washed and rinsed and placed in the hot air oven set at 150°C for 1 hour: 30 minute to undergo sterilization

2.5. Media preparation

2.5.1. Nutrient Agar

A28g of agar was dissolved in 1 liter of distilled water in a conical flask, it was swirled to mix well to attain homogeneity. The conical flask was covered with a cotton wool wrapped in a foil paper, then the medium was sterilized using an autoclave at 121°C for 15 minutes.

2.5.2. Eosin Methylene Blue Agar (Emba)

A 36g of agar was dissolved in 1 liter of distilled water in a conical flask, it was swirled to mix well to attain homogeneity. The conical flask was covered same above and the medium was sterilized using an autoclaved at 121°C for 15 minutes.

2.5.3. Macconkey Broth

A 38g of the agar was dissolved in 1 liter of sterile distilled water in a conical flask, it was swirled to mix to attain homogeneity. The conical flask was covered same above and the medium was sterilized in an autoclaved at 121°C for 15 minutes.

2.5.4. Macconkey Agar

A 48g of the agar was dissolved in 1 liter of distilled water in a conical flask, it was swirled to mix to attain homogeneity. The conical flask was covered same above and the medium was sterilized in an autoclaved at 121°C for 15 minutes

2.5.5. Normal Saline

Sodium chloride of 8.5g was measured and weighed and it was dissolved in 1 liter of distilled water.

2.6. Test For The Ph And Chlorine Residual:

- **pH:** The pH was measured using pH meter (EIL Model 7030 pH meter) with the electrode immersed in sample solution. The reading on the screen were taken and recorded. Buffer solution of known pH was used to calibrate the pH meter.
- **CHLORINE RESIDUAL**: The test kits (HACH Test kit 0 - 3.5mg/l model CN-66F) comes with a disk which has the calibration of different measurement. The disk has different colour of pink and plain and the test kits has 2 tubes, one for the samples containing the reagent and the second one which contain the samples alone which serves as the control. After putting the water into the two tubes, you now matched the disc with the samples when the reagent (tablet) has been pour into it. If there is a colour change you match the disc with whatever colour you found in the samples containing the reagent and that gives you the amount of the chlorine residual present. If there is no chlorine present the water will be clear and that is when it is in 0 mg level.

2.7. Bacteriological Analysis

2.7.1. Total Plate Count

Water sample of 1ml was pour into the plate and 15mls of prepared nutrient agar was pour on it and it was covered, the plate was put in an incubator for an incubation period of 24 hours at 37"c after which bacterial colonies were counted and result was recorded as colony forming unit per 100ml of the water sample. This method was done for all the four water sample collected for both raw and treated water.

2.8. Coliform Test

2.8.1. Presumptive Test (Mpn) Most Probable Number

Each raw and treated water samples of 0.1ml, 1ml and 10ml of each raw and treated water works were pipetted into the test tube already containing single strength macconkey broth of the same quantity respectively e.g 0.Iml of macconkey broth same applied to 1ml and 10ml of the representative sample in multiples of five test tubes for each ml.

All test tubes were incubated at 37°C for 24 hours with the inverted durham tube for collection of gas. Presumptive coliforms count was obtained by making reference to the maccradys probability table (McCrady, 1915). The most probable number [MPN] of coliforms per 100ml of water sample was computed from various combination of positive and negative results obtained from the test tubes.

2.8.2. Presumptive Test

A bijou bottle was clean and sterilize and a durham tube was inverted into the bottle, 10ml of Macconkey broth was measured and pour into the bijou bottle atter which serial dilution of the raw water samples was done then 10ml of water sample was pour into it and was transferred into the incubator at an incubation periods of 37°C for 48 hours. This method was done for all the four samples collected for both raw and treated water.

2.8.3. Confirmatory Test

Transferred made from the positive Macconkey broth with gas and colour change from purple to yellow (positive presumptive test) to the new plate containing prepared Eosin methylene blue (EMB) agar and streaking was done on the plate, the plate was incubated at 37°C for 48 hours. The plate were observed for the growth of a greenish metallic sheen within 48 hours indicating a positive confirmed test, this method was done for the bottles that changes colour and produces a gas.

2.8.4. Completed Test

Isolated colonies from the Eosin methylene blue agar (EMBA) plates was transferred and streaked into the nutrient agar slant, incubated at 37°C for 48 hours, Gram staining was performed on colonies taken from the agar slant. Then after, the API test was carried out on the isolates.

2.9. Gram-Staining Techniques

A thin smear was prepared on a cleaned grease free slide. The smear was allowed to dry and then heat fixed by passing through the flame 3 times gently.

The slide was flooded with the primary stain (crystal violet) for 60 seconds and rinsed with water ‣ It was flooded again with gram's iodine for 60 seconds and was rinsed with water.

75 % ethanol was added as a decolourizer for about 30 seconds and rinsed with water.

Finally, a drop of safranin was added to the slide and left for about 30-60 seconds for counter staining. Then rinsed and slide was left to dry.

A drop of oil was added to the slide and viewed under the microscope for the types of bacteria present either Gram Positive (purple/blue) or Gram Negative (pink/red).

2.10. Biochemical test

2.10.1. Analytical Profile Index

Oxidase Test:

This was detected using a reagent called Tetramethyl-p-phenydiamide dihydrochloride. The test was carried out by picking a colony of the microorganisms and placing it on a filter paper that was been drained with the reagent. A deep purple colour formed within 10 seconds indicates that it is oxidase positive.

2.10.2. Preparation Of The Strip

Before this was carried out oxidase test was done according to the manufacturing instruction for uses.

An incubation box (tray and lid) were prepared and 5ml of distilled water was distributed into the bottom of the tray to create a humid atmosphere

The specimen number was recorded on the elongated flap of the tray.

The strip was then removed from the packaging and placed on the incubator box

2.10.3. Preparation Of The Inoculum

The ampule of API Nacl 0.85% medium (2ml) was opened.

A pipette was used to remove a single well isolated colony from an isolation agar plate.

It was carefully emulsify to achieve a homogenous bacterial suspension which was used immediately after preparation

2.11. Innoculation And Incubation of Strip

NO_3, was inoculated to Oritho-Nitropheny1-D-Galacfopyranosicase (ONPG) by distributing the saline suspension with the tubes. The same pipette was used to avoid the formation of bubbles at the base of the tube, the strip was tilt slightly forward and the tip of the pipette was placed against the set of the cupule.

An ample of APL AUX medium was opened and approximately 200ul of the remaining saline suspension was added to the ampule.

For homogeneity pipette was used to avoid formation of bubbles.

After which the tubes and cupules of tests Glucose GLU, was filled with the suspension.

Mineral oil was added to the cupule of Glucose (GLU), Arginine-Di- Hydrolase (ADH), and Urease (URE) until a convex meniscus was formed.

The incubation box was closed and incubated at 27^{o}C for 24 hours.

2.11.1. No_3 Test

A drop of NIT1 and a drop of NIT2 reagents was added to the GLUCOSE tube.

After 5 minutes it showed a red colour which indicates a positive reaction.

2-3mg of Zinc reagent was added to the GLU tube with the negative reaction. After 5 minutes a tube remaining colourless indicated a positive reaction while a tube with pink - red indicating a negative reaction. This was so because the nitrate present in the tubes were reduced to nitrite by Zinc.

3. Result

The Chlorine residual of the treated water for Iju, Ijanikin, Adiyan and Ikeja was 0 mg/l which means that the residual chlorine in the water samples was nil as shown in Table 1.

The pH of both raw and treated water samples collected from Iju, Adiyan, Ijanikin and Ikeja ranged between 6.7 - 7.1 as shown in Tables 2.

The bacteriological test revealed that both raw and treated water sample collected from Adiyan, Iju and Ijanikin water works in Lagos were mainly contaminated with both pathogenic and non-pathogenic environmental microorganisms but only the raw water samples from Ikeja is the only one that is mainly contaminated with both pathogenic environmental microorganisms as shown in Table 5.

The API results showed that Iju raw and treated water samples has *Klebsiella species*, Adiyan raw water has *Klebsiella pneumoniae* and *Pantoea spp*., Adiyan treated water sample has *Klebsiella pneumoniae.* Ikeja raw water sample has Escherichia coli and Ijanikin raw and treated water samples has *Klebsiella spp*. As shown in Table 8.

Table 1 The residual chlorine and the treated water samples collected from Iju, Adiyan, Ijanikin and Ikeja

Location	Chlorine residual mg/l	Who desirable standard
IJU	0.0	0.1-2.0
ADIYAN	0.0	0.1-2.0
IJANIKIN	0.0	0.1-2.0
IKEJA	0.0	0.1-2.0

Table 2 The pH level of both raw and treated water samples collected from Iju, Adiyan, Ijanikin and Ikeja

Location	Raw water	Treated water	Who desirable standard
IJU	6.9	7.1	6.5-8.5
ADIYAN	6.9	7.0	6.5-8.5
IJANIKIN	6.8	7.0	6.5-8.5
IKEJA	6.7	7.0	6.5-8.5

Table 3 Total plate count obtained from both raw and treated water samples from four different water works in Lagos state

Location	Samples	CFU (ml)
IJU	Treated water Raw water	11 27
ADIYAN	Treated water Raw water	8 26
IJANIKIN	Treated water Raw water	7 20
IKEJA	Treated water Raw water	3 16

Table 4 Presumptive coliforms count of both raw and treated water samples from four different water works in Lagos.

LOCATION	RAW WATER (Number of tubes with positive reaction)			MPN per 100ml	TREATED WATER (Number of tubes with positive reaction)			MPN per 100ml
	10 ml	1 ml	0.1 ml		10 ml	1 ml	0.1 m	
	5	5	5		5	5	5	
IJU	3	2	0	14	3	1	0	11
ADIYAN	4	0	0	13	2	2	0	8
IJANIKIN	2	2	0	8	1	0	1	4
IKEJA	4	0	0	13	3	0	0	8

MPN - Most Probable Number of coliforms obtained from McCrady's probability

Tables 5 The location and Bacterial Morphological characteristics of Raw and Treated water Isolates

Location	Isolates	Bacterial morphology			
		Form	Elevation	Margin	Colour
IJU	Treated water Raw water	Punctiform Punctiform	Flat Flat	Entire Entire	Pink, Green Pink, Green
ADIYAN	Treated water Raw water	Punctiform Punctiform	Flat Flat	Entire Entire	Pink, Green
IJANIKIN	Treated water Raw water	Punctiform Punctiform	No Growth Flat	No Growth Entire	No Growth Pink, Green
IKEJA	Treated water Raw water	Punctiform Punctiform	Flat Flat	Entire Entire	Pink, Green Pink, Green

Tables 6 The location and slide morphological identification of raw and treated water isolates

Location	Isolates	Slide morphological characteristics
IJU	Treated water	Gram-negative short rod in chain

	Raw water	
ADIYAN	Treated water Raw water	Gram-negative short rod in chain
IJANIKIN	Treated water Raw water	Gram-negative bacilli in rod-shaped
IKEJA	Treated water Raw water	Gram-negative bacilli in rod-shaped

Tables 7 The biochemical characteristics of isolates using the Analytical Profile Index (API)

TESTS	**A1**	**A2**	**B1**	**B2**	**C2**	**D1**	**D2**
Oritho-Nitrophenyl-D-Galacto pyrrosidase (ONPG)	+	+	+	+	+	+	+
Lginine-Di-Hydrolase (ADH)	_-	-	-	-	-	-	-
Lysine Decarbovylase (LCD)	+	+	+	+	+	+	+
Orinithine Decarboxylase (ODC)	-	-	-	-	-	-	-
Citrate Production (CIT)	+	+	+	+	+	+	+
Hydrogen Sulphide (H_2S)	-	-	-	-	-	-	-
Urease (URE)	+	-	+	-	-	+	+
Tryptophane De Aminase (TDA)	-	-	-	-	-	-	-
Indole production (IND)	-	-	-	+	+	-	-
Voges-prokauer (VP)	-	+	+	-	-	+	-
Gelatin hydrolysis (GEL)	-	-	-	-	-	-	-
Glucose fermentation (GLU)	+	+	+	+	+	+	+
Mannitol fermentation (MAN)	+	+	+	+	+	+	+
Inosito fermentation (INO)	+	-	+	-	-	+	+
Sorbitol fermentation (SOR)	+	+	+	+	+	+	+
Rhamnose fermentation (RHA)	+	+	+	+	+	+	+
Saccharose fermentation (SAC)	+	+	+	-	-	+	+
Melibiose fermentation (MEL)	+	+	+	+	+	+	+
Amygdalin (AMY)	+	+	+	+	-	+	+
Arabinose fermentation (ARA)	+	+	+	-	+	+	+
Oxidase (OX)	-	-	-	-	-	-	-
Nitrate Reduction (NO_2)	+	+	+	+	+	+	+
Nitrite (N_2)	-	-	-	-	-	-	-
Mobility (MOB)	-	-	-	-	+	-	-
Growth (McC)	+	+	+	+	+	+	+
Fermentation under mineral oil (OF-O)	+	+	+	+	+	+	+

Oxidation exposed to the air (OF-F)	+	+	+	+	+	+	+

KEYS: A1: IJU TREATED ; A2: IJU RAW; B1: ADIYAN TREATED; B2: ADIYAN RAW; C2: IKEJA RAW; D1 IJANIKIN TREATED; D2: IJANKKIN RAW

Tables 8 The identification of the isolated organisms of raw and treated water samples using API test kits

Location	Isolate	Organisms
IJU	Treated water Raw water	*Klebsiella pneumoniae* *Klebsiella terrigena*
ADIYAN	Treated water Raw water	*Klebsiella pneumoniae* *Pantoea spp, Klebsiella pneumoniae*
IJANIKIN	Raw water	*Escherichia coli*
IKEJA	Treated water Raw water	*Klebsiella pneumoniae* *Klebsiella pneumoniae*

4. Discussion

The results of this study highlight significant microbial contamination in both raw and treated water samples from the four major water treatment plants in Lagos—Adiyan, Iju, Ijanikin, and Ikeja. Despite treatment, coliform bacteria were detected in treated water samples, raising concerns about treatment effectiveness and post-treatment contamination. The presence of these bacteria suggests that current water treatment and distribution processes may not be sufficient to ensure microbiological safety, posing a potential public health risk.

4.1. Residual Chlorine and pH Levels

The absence of residual chlorine (0.0 mg/L) in all treated water samples is particularly concerning, as chlorine is the primary disinfectant used to eliminate pathogenic microorganisms and prevent microbial regrowth (WHO, 2022). According to global drinking water guidelines, treated water should contain a chlorine residual of 0.1–2.0 mg/L to maintain disinfection throughout the distribution network (USEPA, 2023). The complete absence of residual chlorine in the treated water samples suggests that either:

- Chlorine was not properly dosed or depleted before reaching consumers.
- Bacterial regrowth occurred due to biofilm formation within aging pipelines.
- Cross-contamination from leaking or corroded pipes introduced new bacteria after treatment.

The pH values (6.7–7.1) recorded in this study fell within WHO's recommended range of 6.5–8.5, indicating that water acidity or alkalinity was not a major concern (WHO, 2017). However, pH alone does not determine microbial safety, as bacteria were still present in the treated water samples despite acceptable pH levels. Studies have shown that while pH control is important for preventing pipe corrosion, it does not guarantee disinfection effectiveness if chlorine levels are insufficient (Singh et al., 2020).

4.2. Bacterial Load and Coliform Contamination

The total bacterial count (TBC) in raw water was highest in Iju (27 CFU/mL) and lowest in Ikeja (16 CFU/mL). After treatment, bacterial counts decreased but were not completely eliminated, with Iju still recording 11 CFU/mL and Ikeja 3 CFU/mL. The presence of bacteria in treated water suggests incomplete disinfection, possibly due to insufficient chlorine dosing, poor filtration efficiency, or biofilm formation within distribution systems (Olanrewaju et al., 2022).

The Most Probable Number (MPN) analysis showed that coliforms were present in all raw water samples, with Iju having the highest count (14 MPN/100mL), followed by Adiyan (13 MPN/100mL), and Ijanikin (8 MPN/100mL). Although coliform counts were reduced in treated water, their persistence (ranging from 4 to 11 MPN/100mL) exceeds the WHO zero coliform per 100mL requirement for potable water (WHO, 2022). This suggests that treatment processes failed to eliminate all bacterial contaminants, or that post-treatment contamination occurred (Afolabi et al., 2019).

The presence of coliform bacteria in treated water is a serious public health concern, as these microorganisms indicate fecal contamination and the possible presence of enteric pathogens such as *Salmonella*, *Shigella*, and *Vibrio cholerae* (Ashbolt, 2015). Inadequate treatment or contamination in the distribution network may expose Lagos residents to waterborne diseases, which remain a leading cause of illness in Nigeria (Adepoju et al., 2020).

4.3. Identification of Bacterial Isolates

Biochemical analysis using the Analytical Profile Index (API) test identified *Klebsiella pneumoniae*, *Escherichia coli*, and *Pantoea spp.* in both raw and treated water samples. The detection of *E. coli* in Ikeja raw water is particularly alarming, as it is a strong indicator of fecal contamination, suggesting that human or animal waste has entered the water source (Olanrewaju et al., 2022).

The presence of *Klebsiella pneumoniae* in multiple treated water samples is concerning, as this bacterium is known to cause respiratory and urinary tract infections, particularly in immuno compromised individuals (Singh et al., 2020). *Pantoea spp.*, though less commonly associated with disease, has been linked to opportunistic infections in hospital settings and indicates environmental contamination (Adegbite et al., 2021).

One major factor contributing to bacterial persistence in treated water is biofilm formation within the water distribution system. Biofilms—microbial communities that attach to pipe surfaces—can protect bacteria from chlorine disinfection and allow pathogenic organisms to survive and multiply (Afolabi et al., 2019). Studies have shown that aging pipelines, intermittent water supply, and low chlorine residuals create ideal conditions for biofilm development, making it difficult to maintain water quality even after treatment (Kumpel & Nelson, 2016).

4.4. Public Health and Infrastructure Concerns

The presence of coliforms and pathogenic bacteria in treated water suggests serious deficiencies in Lagos State's water treatment and distribution infrastructure. A major challenge is the poor condition of pipelines, many of which are old, corroded, and prone to leakage. Studies have shown that water pipes laid through open drains or near sewage lines are at high risk of contamination, especially in urban areas with high population density and poor sanitation (Adepoju et al., 2020).

Additionally, intermittent water supply and low water pressure allow contaminants to enter the system through pipe leaks, increasing the risk of microbial infiltration (Ojo et al., 2021). This problem is compounded by the widespread reliance on alternative water sources—such as boreholes, sachet water, and untreated surface water—which may also be contaminated and contribute to inconsistent water quality (Olanrewaju et al., 2022).

5. Conclusion

The microbial quality of the raw water sources was poor and unacceptable for human consumption due to coliforms pollution. This indicates the potential risk of infection for consumers and calls for prompt intervention to severe the socio-economic and health impact of water-borne diseases on the people consuming it, and this is more reason while the water that will be supply to the public by the water corporation must be properly treated so as to remove all the contaminant in it before supplying it to the public. Government should provide a safe potable water to the public in Lagos state to support the growing population. However there is urgent need for maintaining and replacement of worn-out facilities at different Lagos state water works to eliminate the improper treatment of water.

Recommendations for Improving Water Safety

To ensure the microbiological safety of Lagos' public water supply, several key improvements must be made:

- Improved Chlorination Practices – The absence of residual chlorine suggests insufficient disinfectant dosing. Regular monitoring and automated chlorine adjustments should be implemented to ensure continuous disinfection throughout the distribution network.
- Pipeline Maintenance and Upgrades – Aging and leaking pipes are a major source of contamination. The government should replace corroded pipes, seal leaks, and improve pipeline routing to minimize cross-contamination with sewage.

- Enhanced Microbial Monitoring – Routine testing for coliforms, *E. coli*, and other bacteria should be conducted at multiple points in the water supply chain. Real-time microbial detection technologies should be introduced for early contamination warning.
- Public Awareness and Hygiene Education – Consumers should be educated on safe water storage practices to reduce household contamination. Alternative treatment methods, such as household chlorination and filtration, should also be encouraged.
- Alternative Disinfection Methods – In addition to chlorination, Lagos authorities should explore ultraviolet (UV) disinfection and ozonation, which are effective against chlorine-resistant bacteria and biofilm-associated pathogens.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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