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Research Article

Detection of Faecal Contamination and Pathogenic Escherichia coli in Drinking Water Sources within Kumbotso Local Government Area, Kano State, Nigeria

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ABSTRACT

Background:
This study assessed the microbiological and physicochemical quality of drinking water sources in Kumbotso Local Government Area, Kano State, Nigeria.
Methods: A total of 60 samples were collected from well water, borehole water, and sachet water (20 each). Standard microbiological and physicochemical methods were employed to determine the microbial load, coliform counts, and water quality parameters.
Results: The results revealed significantly higher contamination in well and borehole water compared to sachet water. The mean total coliform count by membrane filtration was 58.42 ± 98.31 CFU/100 mL in well water and 22.75 ± 79.56 CFU/100 mL in borehole water, while sachet water showed no coliforms. Similarly, faecal coliforms were detected in well water (7.65 ± 11.78 CFU/mL) and borehole water (5.20 ± 13.65 CFU/mL), exceeding the WHO guideline of zero. Klebsiella spp. (60.0%) and Escherichia coli (23.6%) were the predominant bacterial isolates, with pathogenic E. coli prevalence of 11.54%. Molecular analysis via 16S rRNA sequencing confirmed E. coli isolates with high similarity (96–98%) to pathogenic strains.
Conclusion: Physicochemical parameters were generally within WHO standards, except turbidity, which exceeded the permissible limit. These findings highlight significant public health risks associated with well and borehole water in Kumbotso LGA, necessitating regular monitoring and improved water treatment strategies.

Keywords: *Drinking, water, Faecal, contamination, Pathogenic, Escherichia coli, Coliform, bacteria, Kano State*

INTRODUCTION

Access to safe and clean drinking water is universally recognized as a fundamental human right, and it is enshrined in the United Nations Sustainable Development Goal (SDG) 6, which seeks to ensure the availability and sustainable management of water and sanitation for all [1]. Despite global efforts, access to potable water remains a pressing challenge, especially in low- and middle-income countries (LMICs), where a significant proportion of the population relies on untreated groundwater and surface water sources. Such dependence exposes millions to faecal contamination and the risk of waterborne pathogens [2].

Globally, contaminated water is estimated to cause approximately 485,000 diarrhoeal deaths annually, with children under five years of age being the most vulnerable [3]. Diarrhoeal and other gastrointestinal diseases are strongly linked to microbial pathogens in drinking water, among which Escherichia coli plays a crucial role as an indicator organism of faecal pollution [4]. The detection of E. coli in drinking water not only signifies recent faecal contamination but also indicates the possible presence of other pathogenic microorganisms, including viruses and protozoa [5].

Although most E. coli strains are harmless commensals of the human gut, pathogenic strains have emerged as major public health concerns. Diarrheagenic E. coli (DEC), which includes pathotypes such as enterotoxigenic (ETEC), enteropathogenic (EPEC), enteroaggregative (EAEC), enteroinvasive (EIEC), and Shiga toxin-producing E. coli (STEC), are associated with severe gastrointestinal diseases, particularly in developing regions [6]. Among these, enterohemorrhagic E. coli (EHEC), such as O157:H7, can lead to haemorrhagic colitis and haemolytic uremic syndrome, conditions that carry significant morbidity and mortality [7]. The detection of pathogenic E. coli in drinking water therefore poses heightened risks beyond general faecal contamination.

In Nigeria, access to safe drinking water is a major public health and developmental issue. Rapid urbanization, population growth, poor sanitation practices, and industrial discharges contribute to the deterioration of water quality, particularly in metropolitan areas such as Kano State [8,9]. Groundwater sources including wells and boreholes remain the primary sources of drinking water for many households due to inadequate piped water infrastructure [10]. However, these sources are often prone to contamination from nearby latrines, open defecation, improper waste disposal, and sewage leakage [11]. Sachet water, commonly referred to as “pure water,” has become an alternative for urban populations, but its quality varies significantly depending on production standards and regulatory compliance [12].

Against this backdrop, it is imperative to assess both the bacteriological and physicochemical quality of drinking water sources in Nigerian communities. Physicochemical parameters such as pH, turbidity, dissolved oxygen (DO), total dissolved solids (TDS), and electrical conductivity are important indicators of water quality, as they can influence microbial survival and proliferation [13]. Turbidity, for example, may provide a protective environment for bacteria and interfere with water disinfection processes [14].

Therefore, this study aimed to investigate the bacteriological and physicochemical quality of drinking water sources in Kumbotso Local Government Area (LGA), Kano State, Nigeria, with a specific focus on faecal contamination and the presence of pathogenic Escherichia coli. Understanding the extent of microbial and chemical contamination in these commonly used water sources is vital for informing public health interventions and ensuring safe drinking water access in the region.

MATERIAL AND METHODS

Study Area

The study was conducted in Kumbotso Local Government Area (LGA), one of the 44 LGAs within Kano State, located in northwestern Nigeria. Kumbotso is part of Kano Metropolis and is characterized by rapid urbanization, dense population, and high reliance on groundwater sources such as wells and boreholes, as well as commercially sold sachet water for domestic consumption [15]. The area falls within the Sudan savanna ecological zone, with a climate marked by distinct wet (May–October) and dry (November–April) seasons, which influences the availability and quality of water sources [16]. The growing population, coupled with poor sanitation infrastructure and improper waste disposal, increases the likelihood of faecal contamination of drinking water sources in the region.

Sample Collection

A total of 60 water samples were collected, comprising 20 samples each from wells, boreholes, and sachet water. Water samples were collected following standard microbiological protocols to minimize external contamination [17]. Sterile 250 mL sampling bottles were used for collection. Borehole samples were obtained after flaming or sterilizing the tap outlet with cotton soaked in 70% ethanol and allowing the water to run for 2–3 minutes before collection [18]. Well water samples were collected by drawing water with a clean container and transferring it aseptically into sterile bottles [19]. Sachet water samples were purchased from local vendors across the study area; the outer surfaces were disinfected with ethanol before aseptically transferring the contents into sterile bottles [12]. All samples were immediately transported in ice-packed coolers to the Microbiology Laboratory at Skyline University, Kano, and processed within 24 hours of collection to preserve sample integrity.

Microbiological Analysis

Total Bacterial Counts

The total viable bacterial counts (TBC) were determined using the pour plate technique as described by Cheesbrough (2006). One milliliter of each water sample was serially diluted in sterile distilled water up to 10^{-3} dilutions, and 1 mL aliquots were plated on nutrient agar. The plates were incubated at 37°C for 24–48 hours, after which discrete colonies were counted and expressed as colony-forming units per milliliter (CFU/mL).

Total and Faecal Coliform Enumeration

Total coliforms were enumerated using the membrane filtration technique in accordance with standard guidelines [20]. Briefly, 100 mL of water was filtered through sterile 0.45 µm membrane filters, which were then placed on pads soaked in membrane lauryl sulphate broth and incubated at 35°C for 24 hours. Colonies were expressed as CFU/100 mL. Faecal

coliforms were assessed using Eosin Methylene Blue (EMB) agar and incubated at 44.5°C for 24–48 hours. Typical dark-centered colonies with metallic sheen were considered presumptive Escherichia coli and further subjected to biochemical identification [21].

Pathogenic E. coli Isolation and Identification

Pathogenic E. coli strains were differentiated using Sorbitol MacConkey Agar (SMAC), which selectively isolates sorbitol non-fermenting strains, including E. coli O157:H7 [22]. Non-sorbitol fermenting colonies were subcultured for purity and subjected to biochemical characterization based on standard taxonomic schemes [23,24]. Confirmatory identification was performed using molecular methods: bacterial DNA was extracted, and the 16S rRNA gene was amplified using PCR. Amplicons were sequenced and compared with GenBank sequences through BLAST analysis for species confirmation [25].

Physicochemical Analysis

Physicochemical parameters were analyzed following standard methods [17]. The parameters assessed included:

- pH and temperature: measured in situ using a calibrated digital pH/temperature meter.
- Turbidity: determined using a turbidity meter, with results expressed in Nephelometric Turbidity Units (NTU).
- Electrical conductivity (EC) and Total Dissolved Solids (TDS): measured with a conductivity/TDS meter.
- Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD): determined by the Winkler titrimetric method.
- Alkalinity, total hardness, and chloride concentrations: determined through titrimetric procedures.

The results of microbiological and physicochemical analyses were compared against World Health Organization [3] standards for drinking water quality to assess compliance and potential health risks.

RESULTS

Enumeration of Bacterial Populations in Water Samples

The microbiological analysis of water sources from Kumbotso Local Government Area (LGA), Kano State, revealed marked variations in bacterial populations among well, borehole, and sachet water samples. The mean total coliform count (TCM) determined by the membrane filtration method was significantly higher in well water (58.42 ± 98.31 CFU/100 mL) and borehole water (22.75 ± 79.56 CFU/100 mL) compared to sachet water, which showed no detectable coliforms (0.00 ± 0.00 CFU/100 mL). Similarly, using the pour plate method on MacConkey agar, well water (7.85 ± 10.12 CFU/mL) and borehole water (6.95 ± 16.87 CFU/mL) exhibited higher coliform counts relative to sachet water (0.85 ± 2.94 CFU/mL).

Faecal coliforms were also present in well (7.65 ± 11.78 CFU/mL) and borehole water (5.20 ± 13.65 CFU/mL), whereas sachet water showed none (0.00 ± 0.00 CFU/mL). The total bacterial count (TBC) followed a similar pattern, with well water (19.80 ± 15.65 CFU/mL) and borehole water (13.95 ± 21.45 CFU/mL) significantly exceeding sachet water (6.95 ± 13.75 CFU/mL). These findings demonstrate the vulnerability of untreated groundwater to

microbial contamination, in line with previous studies in Nigeria and other developing countries [9,11].

Table 1: Mean Total and Faecal Coliform Counts of Water Samples in Kumbotso LGA

Sample	TCM (CFU/100 mL)	TBC (CFU/mL)	TC (CFU/mL)	TFC (CFU/mL)
Sachet Water	0.00 ± 0.00^{a}	6.95 ± 13.75^{a}	0.85 ± 2.94^{a}	0.00 ± 0.00^{a}
Well Water	58.42 ± 98.31^{b}	19.80 ± 15.65^{b}	7.85 ± 10.12^{b}	7.65 ± 11.78^{b}
Borehole Water	22.75 ± 79.56^{ab}	13.95 ± 21.45^{ab}	6.95 ± 16.87^{b}	5.20 ± 13.65^{b}
WHO Standard	0	$\leq 1.0 \times 10^{2}$	0	0

Keys: TCM = Total coliform count (Membrane Filtration); TBC = Total Bacterial Count; TC = Total Coliform Count; TFC = Total Faecal Coliform Count. Values are mean ± SD. Values with different superscripts (^{a},^{b}) differ significantly at $p < 0.05$.

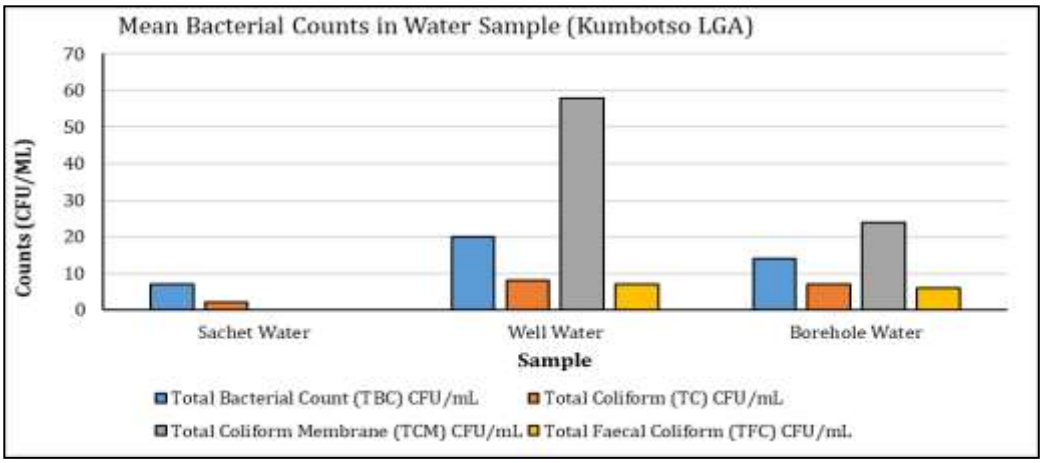

Figure 1. Coliform Population Patterns in Water Samples

Coliform Population Patterns in Water Samples

The bacterial isolates recovered from the water samples revealed distinct species distribution patterns. In well water, Klebsiella spp. (55.7%) was the most prevalent, followed by E. coli (25.5%), Enterobacter spp. (11.4%), Salmonella spp. (6.0%), and Citrobacter spp. (1.3%) (Table 2). Borehole water followed a similar trend, with Klebsiella spp. (68.4%) dominating, followed by E. coli (19.7%), Enterobacter spp. (9.2%), and Citrobacter spp. (2.6%) (Table 3).

Table 2: Frequency of Coliform Isolates from Well Water

Bacterial Isolate	Frequency	Percentage (%)
Escherichia coli	38	25.5
Klebsiella spp.	83	55.7
Enterobacter spp.	17	11.4
Salmonella spp.	9	6.0
Citrobacter spp.	2	1.3
Total	149	100

Table 3: Frequency of Coliform Isolates from Borehole Water

Bacterial Isolate	Frequency	Percentage (%)
Escherichia coli	15	19.7
Klebsiella spp.	52	68.4
Enterobacter spp.	7	9.2
Citrobacter spp.	2	2.6
Total	76	100

Across all water sources, a total of 225 bacterial isolates were obtained, with Klebsiella spp. (60.0%) being the most dominant, followed by E. coli (23.6%), Enterobacter spp. (10.7%), Salmonella spp. (4.0%), and Citrobacter spp. (1.8%) (Table 4).

Table 4: Overall Distribution of Coliform Isolates

Bacterial Isolate	Frequency	Percentage (%)
Escherichia coli	53	23.6
Klebsiella spp.	135	60.0
Enterobacter spp.	24	10.7
Salmonella spp.	9	4.0
Citrobacter spp.	4	1.8
Total	225	100

These findings corroborate earlier studies reporting Klebsiella and E. coli as the dominant coliforms in Nigerian groundwater [8]. The detection of Salmonella spp. further underscores the risk of waterborne typhoid and gastroenteritis.

Detection of Pathogenic Escherichia coli

Differentiation on Sorbitol MacConkey Agar (SMAC) revealed non-sorbitol fermenting E. coli strains, suggestive of pathogenic variants. Out of 53 E. coli isolates, 6 were pathogenic, giving a prevalence of 11.54%. These isolates are of public health concern, as pathogenic E. coli

are implicated in diarrhoea, haemorrhagic colitis, and haemolytic uremic syndrome [6].

Molecular Identification

Molecular analysis using 16S rRNA sequencing confirmed three selected isolates (ww4, ww13, wb6) as E. coli, with sequence similarity ranging between 96–98% to pathogenic strains in the NCBI database (Table 5).

Table 5: Molecular Identification of Pathogenic E. coli Isolates

Sample ID	Scientific Name	Max Score	Query Cover	% Identity	Accession No.
ww4	*Escherichia coli*	2592	98%	98.86%	OR462686
ww13	*Escherichia coli*	1725	96%	99.80%	KJ477003
wb6	*Escherichia coli*	1725	100%	99.89%	ON921233

Physicochemical Characteristics of Water Samples

The physicochemical parameters of water samples are summarized in Table 6. Most values were within WHO (2017) permissible limits, except turbidity, which consistently exceeded the recommended threshold of <5 NTU across all water sources. Elevated turbidity suggests suspended solids and microbial presence, which can shield pathogens from disinfection [14].

Table 6: Physicochemical Properties of Water Samples in Kano

Sample	pH	Temp (°C)	Turbidity (NTU)	TH (mg/L)	TDS (mg/L)	Conductivity (µS/cm)	Alkalinity (mg/L)	Cl (mg/L)	DO (mg/L)	BOD (mg/L)	WHO Standard
Range	6.62–8.45	28.7–29.8	11	34–250	12.3–97.8	22–200.5	33.5–34.5				

DISCUSSION

This study assessed the bacteriological and physicochemical quality of drinking water sources in Kumbotso LGA, Kano State. The findings revealed that well and borehole water harbored significantly higher total and faecal coliform counts compared to sachet water, which showed no detectable contamination. These results exceed the World Health Organization (WHO) guideline of zero coliforms in drinking water [3], underscoring potential health risks, including malnutrition because of high sickness frequencies [26]. Similar studies in Nigeria and other developing regions have reported high coliform contamination in untreated groundwater, often linked to poor sanitation, open defecation, and proximity of wells to latrines [11].

The bacterial isolates were dominated by Klebsiella spp. (60.0%) and Escherichia coli (23.6%), consistent with earlier reports from Nigerian groundwater [27]. While coliforms may not directly cause disease,

their presence signals faecal pollution and the possible coexistence of pathogenic microorganisms [28]. The detection of Salmonella spp. in this study further highlights risks of waterborne infections such as typhoid fever.

Pathogenic E. coli strains were identified in 11.54% of isolates, with molecular confirmation via 16S rRNA sequencing showing 96–98% similarity to pathogenic strains. These findings are comparable to reports from other LMICs, where pathogenic E. coli prevalence in drinking water has ranged between 1–26% [7]. Their occurrence reflects faecal contamination from human and animal waste and aligns with studies documenting the persistence of diarrheagenic E. coli in African water systems [22].

The physicochemical assessment showed most parameters within WHO limits, except turbidity, which consistently exceeded permissible levels. Elevated turbidity can reduce disinfection efficiency and provide a protective niche for pathogens [14]. Similar findings were reported in groundwater from Nigeria and Kenya, where high turbidity correlated with microbial contamination [29]. However, this study demonstrates that untreated groundwater sources in Kumbotso LGA are vulnerable to faecal contamination and pathogenic bacteria, representing a significant public health concern. Interventions such as improved well construction, regular monitoring, safe storage, and community-level water treatment are urgently needed to mitigate risks and ensure compliance with international drinking water standards.

CONCLUSION

This study evaluated the microbiological and physicochemical qualities of drinking water sources in Kano Metropolis, with particular focus on well water, borehole water, and sachet water. The results revealed that well and borehole water were more prone to faecal contamination compared to sachet water, which showed no detectable coliform growth. Elevated total and faecal coliform counts, alongside the isolation of Klebsiella spp. and Escherichia coli, highlight significant microbial risks. Importantly, molecular analysis confirmed the presence of pathogenic E. coli strains with high sequence similarity to reference pathogenic isolates, underscoring the potential for waterborne disease transmission.

Physicochemical parameters were generally within WHO permissible limits, except for turbidity, which exceeded recommended thresholds in all water sources. Elevated turbidity suggests the likelihood of suspended particles that may protect microorganisms from disinfection, further compounding microbial risks. Overall, the findings demonstrate that untreated groundwater sources in Kano remain vulnerable to contamination and pose a significant public health challenge.

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