



Research Article

Occurrence and Distribution of *Escherichia coli* in Water Sources within Maiduguri Metropolitan Council, Borno State, Nigeria

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ABSTRACT

Escherichia coli poses a serious public health risk, especially in areas where water supplies are vulnerable to faecal pollution. This research work was designed to determine the occurrence of *E. coli* in water supplies and assess the potability of water in Maiduguri, Borno State, Nigeria, including hitherto uncharted territories. A total of seventy (70) water samples were aseptically collected in sterilized containers from wash boreholes and surface water reservoirs. Ten samples each were collected from seven wards within the Maiduguri metropolis using simple random sampling. The wards were Bolori, Bulabulin, Gwange I, Gwange III, Hausari, Mafoni, and Shehuri. The water samples were collected in sterile sample bottles, placed in an ice container, and transported immediately for analysis at the Veterinary Public Health and Preventive Medicine Laboratory, Faculty of Veterinary Medicine, University of Maiduguri. The result of this study revealed that wash boreholes have a higher mean colony-forming unit/millilitre (13.32) of *E. coli* than surface water reservoirs (10.12). However, the water sources do not differ significantly from each other ($p=0.914$). Of the seven wards (localities) from which samples were obtained, Hausari had the highest mean colony-forming unit (15.50), while the lowest colony-forming unit was obtained from Bulabulin (11.60). However, the locations did not differ significantly from one another ($p=0.321$). Therefore, the government water treatment plant and households should implement stricter safeguards to prevent the spread of *E. coli* in water.

Keywords: Enterobacteriaceae; *Escherichia coli*; Maiduguri; Wash borehole; Surface reservoirs; Water

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INTRODUCTION

Escherichia coli (*E. coli*) is a Gram-negative rod-shaped bacterium belonging to the Gamma proteobacteria class and the Enterobacteriaceae family (Almagro *et al.*, 2015; Svanberg *et al.*, 2021). This bacterium may replicate in around 20 minutes when growing conditions are ideal (Wang *et al.*, 2010). Although *E. coli* is known to live as commensals in the gastrointestinal tracts of humans, pests, ruminants, non-ruminants, and wild animals (Almansour *et al.*, 2023), pathogenic *E. coli* is known to cause disease and are typically spread by consuming contaminated food or water, such as raw

milk, undercooked meat, and meat products. The organism has been known to cause outbreaks of foodborne and waterborne diseases across the globe (Malabadi *et al.*, 2024). The organism is excreted in faeces and can be spread by feeding on contaminated food or water or by contact with animals or infected humans. It is present in the stool of infected individuals with diarrhoea and for a while after the disease (Garcia *et al.*, 2019).

In the Maiduguri metropolis, there is limited documented information on the occurrence of *E. coli* in

commonly used water sources such as wash boreholes and surface reservoirs. A wash borehole is a borehole that has been drilled using the auger boring method, where water is used as the drilling fluid to remove cuttings and debris. It is a shallow borehole drilled manually, usually between 15m to 30m deep suitable for either private or domestic use (Garg, 1993). This lack of data hinders effective monitoring and control measures. Therefore, it is necessary to assess the occurrence and distribution of *E. coli* in these water sources to determine their safety for human consumption and guide public health interventions. This study contributes to understanding the epidemiology and occurrence of *E. coli* in water in Maiduguri.

MATERIALS AND METHODS

Collection of Samples

A total of seventy (70) water samples were aseptically collected from the wash borehole and surface reservoirs into sterilized containers. Ten (10) samples each were collected from seven (7) wards within Maiduguri metropolis using simple random sampling. The wards were Bolori, Bulabulin, Gwange I, Gwange III, Hausari, Mafoni, and Shehuri. Emphasis was placed on strategic areas that function as public and/or commercial water sources, which were identified as spots where street vendors gathered water in jerry cans before selling to customers. The water samples were collected in sterile sample bottles, placed in an ice container, and transported immediately for analysis at the Veterinary Public Health and Preventive Medicine Laboratory, Faculty of Veterinary Medicine, University of Maiduguri.

Presumptive Detection of *E. coli* by MPN Approach Using Lactose Broth

In accordance with Thomas *et al.* (2015) methodology, a serial dilution was performed. Three sets of tubes were inoculated with each sample in the manner described below: 10 ml was first added to a tube that held 40 ml of lactose broth, which is typically referred to as double-strength lactose broth (DSLB) with Durham tubes. Next, 1.0 ml of the 20 ml lactose broth, which is typically referred to as single-strength lactose broth (SSLB) with Durham tubes, was added. Finally, 0.1 ml was inoculated into three tubes, each holding 20 ml of lactose broth, which is typically referred to as single strength lactose broth (SSLB) with Durham tubes. After being incubated for 24 to 48 hours at 37 °C, the tubes were examined for both positive and negative reactions. The presence of *E. coli* was confirmed by the murky or cloudy appearance of the positive tubes, which showed gas formation, but the negative tubes showed no signs of gas formation and were transparent.

Isolation and Biochemical Identification of *E. coli*

The following selective and differential media were used per the manufacturer's instructions and the procedure elaborated by Onuorah *et al.* (2016): MacConkey Agar, Blood Agar, Mannitol Salt Agar, Eosin Methylene Blue (EMB), Peptone water, Lactose Broth (Single Strength), and Lactose Broth (Double Strength). The water sample was streaked onto MacConkey agar plates (differential media for *E. coli* identification) using a wire loop. For around fifteen minutes, the plates were left to dry with their covers on. The plates were then turned upside down and incubated for twenty-four hours at 37°C. The plates were inspected for both typical and atypical colonies following incubation. *Escherichia coli* colonies grown on MacConkey agar were typically observed to be medium in size, dry, and pink, and they could be seen alone or in clusters. Atypical colonies showed up as tiny, crimson colonies that may be observed alone or in groups.

Confirmation of *E. coli*

Gram staining, catalase, coagulase, citrate utilization, sugar (glucose, sucrose, fructose, and galactose) fermentation, motility, and spore tests were performed to identify the bacterial isolates as outlined by Onuorah *et al.* (2016).

Data Analysis

Data obtained from this study were subjected to normal statistical distribution as mean $\pm$ standard deviation and percentage. An independent sample test and ANOVA were used to test whether there were statistically significant differences in *E. coli* contamination (measured in CFU) between different water sources and among the various wards/locations respectively. The statistical software used for the analysis was SPSS version 16.0.

RESULTS

The findings from analysis of water samples collected from surface reservoirs and wash boreholes indicated that the mean contamination level for surface reservoirs was 10.12 ± 1.57 CFU/ml, and that of wash boreholes was 13.32 ± 1.23 CFU/ml. However, there is no statistically significant difference between the water sources ($p=0.914$) (Table 1).

The mean total aerobic count (CFU/ml) of water samples collected from different communities, respectively, were as follows: Bolori – 14.90 ± 2.47 ; Bulabulin – 11.60 ± 2.76 ; Gwange 1 – 14.00 ± 3.00 ; Gwange 3 – 14.30 ± 2.98 ; Hausari – 15.50 ± 2.12 ; Mafoni – 12.50 ± 2.92 ; and Shehuri – 13.40 ± 3.41 . The results showed varying mean contamination levels, where Hausari had the highest mean (15.50 CFU/ml), and the lowest mean was from Bulabulin (11.60 CFU/ml). However, there is no significant statistical difference in

mean total aerobic counts of water samples across the locations ($p=0.321$) (Table 2).

The occurrence of *E. coli* isolated, based on inoculation volumes, indicated that Gwange 3 had the highest positivity rate (90%), followed by Gwange 1 with 80%,

Hausari with 70%, Bulabulin with 50%, and Mafoni with the lowest at 30%. However, location and inoculation status significantly affect the number of *E. coli* isolated, but there is no significant interaction between them ($p=0.001$) (Table 3).

Table 1. Mean total aerobic count of different water sources in Maiduguri Metropolis

Water Sources	n	Mean (CFU/ml)	Standard Deviation	P-value for t-Test
Surface reservoir	25	10.12	1.57	0.914
Wash Borehole	45	13.32	1.23	

Table 2. Distribution of mean total aerobic count of water samples based on sampling locations

Location	Mean	Standard Deviation	P-value for F-Test
Bolori	14.90	2.47	0.321
Bulabulin	11.60	2.76	
Gwange 1	14.00	3.00	
Gwange 3	14.30	2.98	
Hausari	15.50	2.12	
Mafoni	12.50	2.92	
Shehuri	13.40	3.41	

Table 3. Occurrence of *E. coli* in water sources across locations in Maiduguri metropolis

Location	Number examined	Number and percentage (%)		P-value for F-Test
		Negative	Positive	
Bolori	10	6(60)	4(40)	0.001
Bulabulin	10	5(50)	5(50)	
Gwange 1	10	2(20)	8(80)	
Gwange 3	10	1(10)	9(90)	
Hausari	10	3(30)	7(70)	
Mafoni	10	7(70)	3(30)	
Shehuri	10	2(20)	8(80)	

DISCUSSION

The findings presented in this study highlight variations in water contamination levels across different water sources and communities, as well as the presence of *E. coli*, a key indicator of faecal contamination. The results provide critical insights into the quality of water sources and the potential health risks associated with their use. The study revealed that wash boreholes had a higher mean contamination level compared to surface reservoirs. This disparity may be attributed to the proximity of wash boreholes to sources of faecal contamination, such as septic tanks, latrines, or agricultural runoff. Wash boreholes, often shallow and poorly constructed, are more susceptible to contamination from surface water infiltration (Graham and Polizzotto, 2013). In contrast, surface reservoirs, while still vulnerable, may benefit from natural sedimentation processes that reduce microbial loads (WHO, 2017). The higher contamination in wash boreholes underscores the need for improved

construction and maintenance practices to prevent groundwater pollution.

The distribution of water samples across communities showed significant variations in contamination levels. These variations may be influenced by factors such as population density, sanitation infrastructure, and land use practices. High contamination levels in Hausari and Bolori could be linked to inadequate sanitation facilities and poor waste management, which are common in densely populated urban areas (Howard *et al.*, 2003). Conversely, lower contamination in Bulabulin may reflect better water source protection or lower population pressure.

The high occurrence of *E. coli* in this study highlights the extent of faecal contamination in the studied communities. The high *E. coli* prevalence in Gwange 3 and Gwange 1 suggests significant faecal contamination, likely due to inadequate sanitation and the proximity of water sources to human and animal waste (Bain *et al.*, 2014). *Escherichia coli* is a reliable indicator of faecal contamination and poses serious health risks, including

diarrheal diseases and other waterborne illnesses (Cabral, 2010). The lower occurrence rate in Mafoni may indicate better water source management or lower contamination pressures.

The findings underscore the urgent need for targeted interventions to improve water quality in the studied communities. High contamination levels and *E. coli* positivity rates highlight the risk of waterborne diseases, particularly in communities with poor sanitation infrastructure. Strategies such as improved borehole construction, regular water quality monitoring, and community education on hygiene practices are essential to mitigate these risks (WHO, 2017). Additionally, the implementation of water treatment technologies, such as chlorination or filtration, could reduce microbial contamination and improve water safety (Clasen *et al.*, 2015).

CONCLUSION

This study provides valuable insights into the contamination levels of water sources across different communities in Maiduguri metropolis, emphasizing the need for urgent action to address water quality issues. The higher contamination in wash boreholes and the varying contamination levels across communities highlight the role of environmental and socio-economic factors in water quality. Therefore, it is advised that in order to prevent the spread of *E. coli* in public water supplies, the government should enforce stringent measures towards safeguarding water treatment plants and household water supplies.

Conflict of Interest

There is no conflict of interest to declare.

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