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Public Health Implications of Shigella Contamination in Borehole Water Sources in Uli Community

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Abstract

This study investigates the prevalence of *Shigella* species in borehole water samples from Uli community, with a focus on antibiotic resistance. *Shigella dysenteriae*, a dominant species, poses significant health risks due to its ability to cause human infections and develop antibiotic resistance, with 80% of resistant genes encoded in plasmids. A cross-sectional study was conducted, collecting borehole water samples from various markets and locations in Uli community using standard microbiological techniques. The samples were cultured in Deoxycholate Citrate Agar in appropriate growth conditions. The isolates obtained were characterized appropriately, and their occurrences was in the samples was also determined. Chi-square tests were used to determine the significance of the prevalence rates. The results indicate a statistically significant difference in the occurrence of *Shigella* strains ($p < 0.05$). The results of this study revealed the presence of three *Shigella dysenteriae* strains: SD53, SD07, and SDBU. Statistical analysis showed that 50% of the samples were positive for SD53, while SD07 and SDBU occurred at rates of 19.44% and 30.56%, respectively. The study demonstrates that different strains of *Shigella* species are present in borehole water in Uli community, with SD53 being the most predominant strain. These findings highlight the need for regular monitoring of water sources and implementation of effective water treatment strategies to prevent the spread of waterborne diseases.

Keywords: Maternity care providers, Waterbirth, Implementation, Facilitator, Barriers, Abuja, Tertiary hospitals

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1. Introduction

Water is a clear, tasteless, and odorless liquid in its pure form, essential for all forms of life. It falls from clouds as rain and flows into rivers and seas. According to the World Health Organization and UNICEF, approximately 2.1 billion people globally lack access to safe and readily available water at home (UNICEF, 2019). In response to this crisis, the present study aims to assess the microbiological quality of

borehole water in Uli community, Ihiala Local Government Area, Anambra State, Nigeria, to determine its suitability for human consumption.

Accessing clean and potable water remains a significant challenge globally, particularly in communities where water sources are vulnerable to contamination (Eze *et al*., 2013). Boreholes, which are deep, narrow holes drilled into the ground to access groundwater, serve as a primary source of drinking water for many. However, human activities such as indiscriminate defecation, improper disposal of industrial effluents, and dumping of refuse and sewage into water bodies compromise the quality of these water sources, contributing to the spread of waterborne diseases like cholera and shigellosis.

Shigella, a genus of Gram-negative bacteria, is one of the pathogens of concern in water sources. It is known to cause infections across all age groups, particularly affecting vulnerable populations such as the very young, the elderly, and immunocompromised individuals. Despite its significance, some researchers have noted the genetic and phenotypic similarities between *Shigella* and *Escherichia*, suggesting they could be considered a single genus (Mumy, 2014). The presence of *Shigella* in water sources highlights the need for proper examination and detection of indicator organisms to assess the microbial quality of water.

This study aims to investigate the prevalence of *Shigella* species in borehole water samples in the Uli community, where borehole water is a primary source of drinking water. The study's findings will contribute to the limited data available on the microbiological quality of borehole water in this community, providing insights into the potential health risks associated with consuming this water source. Other bacterial isolates identified in the study.

2. Materials and Methods

Isolation and Characterization of *Shigella* Species

Sample collection, handling and transportation: The samples used for this study were drawn from the rivers. A total of 100 freshwater samples were collected from five different streams used in Uli community. Samples were taken from twenty different sites, each site in triplicates. The stream samples were collected with sterile containers. The containers were thoroughly washed with detergent, rinsed with water, and then rinsed with 70% ethanol and final rinsed three times with distilled water. The containers were placed inverted in order to drain the water inside them. The container was inverted and lowered 5 cm below the river water sample, then placed vertically for the water sample to refill the sample container. This sample was covered immediately and kept in a cooler containing ice block, and this transported to the laboratory for immediate analysis.

Isolation of organisms

One milliliter (1.0 ml) water sample was aseptically transferred into a sterile test tube (Pyrex) containing 9.0 ml of the diluent (sterile normal saline) and from this; ten-fold serial dilutions were made up to 10-3. One milliliter of the diluted sample (10-3) was plated on Petri dishes (60 mm OD × 55 mm ID × 13mm high) containing Deoxycholate agar medium (DCA/Biotech) using pour plate method. All the plates in triplicates were incubated inverted at 37±2˚C for 24-48 h.

Characterization and identification of the isolates

The isolates were sub cultured on nutrient agar (Biotech), incubated in inverted position at 37±2°C for 24 h. The isolates were characterized and identified using their colonial and morphological descriptions as described in the study published by Iheukwumere *et al*. (2018), Iheukwumere *et al*. (2025a), and Iheukwumere *et al*. (2025b), biochemical reactions as described in the study published by Iheukwumere *et al*. (2020) and molecular characterization as described in the study published by Gabriela *et al*. (2014). The colonial description was carried out to determine the colours of the isolates on agar media plates, their sizes, edges, consistencies and optical properties of the isolates.

Prevalence and Distribution of the Isolates in the Stream Samples

The number each bacterial isolate in each sampling area were enumerated, and these were calculated in percentage of the occurrences. The bacterial that appeared in each sample location were detected and recorded as described in the study published by Iheukwumere *et al* (2021), Abiodum *et al*. (2024b).

Statistical Analysis

The results of the data generated were expressed as mean, percentage and Table, Data were analyzed by two-way Analysis of Variance (ANOVA) to determine the significance of the main effects and interactions at 95 % confidence level. Pair wise comparison of mean was done by Student “t” test as described in the study published by Iheukwumere *et al.*, (2018)., Ekesiobi *et al*. (2017), Abiodum *et al*. (2024a), Ekesiobi, (2025), Iheukwumere *et al*. (2025c), Iheukwumere *et al*. (2025d), Iheukwumere *et al*. (2025e) and Abiodum *et al*. (2024c).

3. Results

The occurrences of the Isolates in the sample is showed in Table 1. The study revealed that 36% of the samples were positive for *Shigella* species. Sample c showed highest occurrences of the Test Organism whereas sample B recorded the lowest occurrences

The cultural and morphological characteristics of the Isolates is shown in Table 2. The study revealed that the Isolates exhibited different appearances on Deoxychocolate citrate agar and similar elevation, Edge and surface. And also similar morphological characteristics on Gram reaction, cell morphology, Endospores and motile nature. The biochemical characteristics of the Isolates revealed that the Isolates were Voges prokaver, I dole, Citrate, Hydrogen sulphide production, Urease, Dulcitol and Sucrose negative as shown in Table 3. The Isolates differ in their variation in utilization of sugars. They were all catalase and Glucose positive but differ in their abilities to utilize Lactose, Mannitol and Inositol. The nucleic acid extracted from the Isolates showed the ratio of their absorbance at wave length of 260 nm and 280 nm. using Nano drop was at the range of

1.80 —1.90, and this confirmed that the nucleic acids were DNA as shown in Table 4. The molecular identities of the Isolates revealed that Isolate E, F and G were *Shigella dysenteriae* strain 53—3937(SD53), *Shigella dysenteriae* strain 07—3308(SD07) and *Shigella dysenteriae* strain BU53W(SDBU) as shown in Table 5

The study also revealed that SD53 showed highest occurrences in the studied sample where as SD07 recorded the least occurrences as shown in Table 6.

Table 1: Occurrences of the Isolates in the studied samples

Sample	Number	P(%)	N(%)
A	20	7(35.00)	13(65.00)
B	20	4(20.00)	16(80.00)
C	20	13(65.00)	7(35.00)
D	20	5(25.00)	15(75.00)
E	20	7(35.00)	13(65.00)
Total	100	36(36.00)	64(64.00)

Table 2: Cultural and morphological characteristics of the Isolates

Parameter	E	F	G
Appearance on DCA	Colourless/pale	Pale	Colourless
Elevation	Convex	Convex	Convex
Edge	Smooth	Smooth	Smooth
Surface	Smooth	Smooth	Smooth
Gram reaction	____	____	____
Cell morphology	Rods	Rods	Rods
Endospore	____	____	____
Motility	____	____	____

Table 3: Biochemical characteristics of the Isolates

Parameter	E	F	G
Catalase	+	+	+
Voges prokaver	_	_	_
Indole	_	_	_
Citrate	_	_	_
H_2S	_	_	_
Urease	_	_	_
Glucose	+	+	+
Lactose	+/-	_	+/-
Mannitol	+/-	+/-	+
Dulcitol	_	_	_
Sucrose	_	_	_
Inositol	_	+/-	_

Table 4: Molecular characterization of the isolates

Parameter	E	F	G
Max Score	6076	6076	7239
Total score	6076	6076	15503
Query score (%)	100	100	100
E-value	0.0	0.0	0.0
Identity (%)	100	100	100
Accession Number	4382743	4382687	184894
Description	*Shigella dysenteriae* strain 53-3937 (SD53)	*Shigella dysenteriae* strain 07-3308 (SD07)	*Shigella dysenteriae* strain BU53W (SDBU)

Table 5: Occurrence of the isolates

Isolate	Number	Percentage (%)
SD53	18	50.00
SD07	7	19.44
SDBU	11	30.56
Total	36	100

4. Discussion

The presence of *Shigella* in the studied borehole water samples could be traced from the management practices, poor handling and sanitary conditions attributed to the samples. Similar findings were reported by many researchers (Immerseel *et al.*, 2014; Jones and Richardson, 2014; Alshawabkeh, 2016; Maciorowski *et al.*, 2017). Researchers had shown that poor hygiene can also harbour *Shigella*, and this contributes to the contamination of water also stated that the high prevalence and high populations of *Shigella* in borehole water was evidence that borehole water could be a principal source of *Shigella* (Iheukwumere *et al.*, 2018a; Iheukwumere *et al.*, 2018b; Kupryś-Caruk *et al.*, 2018). Water contaminated by enteric bacteria pathogenic to humans can contribute to human water-borne illness through the water-food-human chain. This shows that borehole water requires microbiological safety regulations to escape microbial contamination of the product. The variation of strains of *Shigella* species from different locations of the borehole water studied could be attributed to the anthropogenic activities around the water body

The presence of *Shigella dysenteriae* strain 53—3937(SD53), *Shigella dysenteriae* strain 07-3308(SD07) and *Shigella dysenteriae* strain BU53W(SDBU) from studied borehole water samples supported the occurrence of enteric bacteria in the samples. The highest counts of *Shigella* recorded among different samples of borehole water collected from different water bodies could be attributed to the poor handling, poor sanitation and a series of anthropogenic activities around the water bodies. Similar findings were stated by many researchers (Davies and Wales, 2010; Ali *et al.*, 2014).

5. Conclusion

This study identified three *Shigella dysenteriae* strains (SD53, SD07, and SDBU) in water samples, with SD53 predominantly found in borehole samples. To control *Shigella* transmission, the study emphasizes the importance of personal hygiene and community education, highlighting these practices as effective strategies for prevention.

Conflicts of Interest

Authors declare that there is no conflict of interest

Ethical approval and consent to participate

Approvals were obtained from the institutions and consent from participants

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