

Contamination to Prevention: Addressing Microbial Pollution in Water Sources across Rainy and Dry Seasons in Ikpoba Okha Local Government Area, Nigeria

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Abstract

Background: Waterborne diseases remain a major public health concern, particularly in developing countries where access to safe water is limited. Seasonal changes can significantly influence microbial contamination levels in water sources, increasing risks to human health. **Aim and Objectives:** This study aimed to assess the microbial quality of water sources in Ikpoba Okha Local Government Area (LGA), Nigeria, during the rainy and dry seasons, and to identify the prevalence of key waterborne pathogens. **Materials and Methods:** Water samples were collected from five rivers (Ikpe, Ologbo, Ossiomo, Uteh, and Ikpoba), five wells, and eight boreholes across eight communities. Two samples were obtained from each river, five from wells, and eight from boreholes in both seasons. Standard microbiological methods were used to detect and quantify *Escherichia coli*, *Salmonella*, *Shigella*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Vibrio cholerae*, and *Proteus* species. **Results:** High levels of microbial contamination were observed. *Salmonella* and *Shigella* were detected in 8 of 10 samples, while *E. coli* was widespread, with higher counts in the dry season. *P. aeruginosa* and *S. aureus* showed seasonal variation, with *S. aureus* more prevalent in the rainy season. *V. cholerae* and *Proteus* species were also present with fluctuating seasonal patterns. **Conclusion:** Water sources in Ikpoba Okha LGA are significantly contaminated with pathogenic microorganisms, posing a serious public health risk. There is an urgent need for regular water quality monitoring, improved sanitation infrastructure, and targeted community health interventions to reduce waterborne disease transmission.

Keywords: Contamination, disease, environmental, sustainability, water quality

INTRODUCTION

Access to clean and safe drinking water remains a critical public health issue, especially in developing regions like Nigeria, where many communities rely on boreholes and wells as primary water sources.^[1] In Ikpoba Okha Local Government Area (LGA), located in southern Nigeria, these water sources are increasingly vulnerable to microbial contamination, raising concerns about waterborne diseases and overall water quality.^[2] The challenge is exacerbated by seasonal variations, as heavy rains during the wet season often lead to surface runoff and flooding, which can introduce contaminants into shallow groundwater systems. Conversely, the dry season brings reduced water flow, increasing the concentration of pollutants and the likelihood of microbial persistence.^[3] Understanding how these seasonal shifts influence microbial pollution in

boreholes and wells is essential for improving water quality and safeguarding public health. Despite the widespread reliance on these water sources, limited research has explored the seasonal dynamics of microbial contamination in Ikpoba Okha LGA, creating a significant knowledge gap. The quality of boreholes and well water in Ikpoba Okha LGA, Edo State, is influenced by chemical and physical factors, but microbial

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contamination is crucial in understanding waterborne diseases. Research shows that, although the physicochemical properties of the water often fall within acceptable standards, microbial contamination presents serious health risks, highlighting the need for a thorough evaluation of all aspects of water quality.^[4] Moreover, while seasonal variation is a recognized factor in water quality, there is a lack of localized studies that assess how rainy and dry seasons affect microbial populations in boreholes and well water. Addressing this gap is essential for developing context-specific strategies to reduce microbial pollution and improve water safety. The primary objective of this study is to assess the microbial quality of boreholes and well water sources in Ikpoba Okha LGA across both rainy and dry seasons to identify the prevalence of key microbial pathogens, such as *Escherichia coli*, *Salmonella*, and *V. cholerae*, and evaluate how seasonal changes influence contamination levels. In addition, the study seeks to recommend preventive measures to minimize microbial contamination and propose strategies for ensuring the safety of these water sources. The findings of this study have significant implications for public health and water management. Understanding seasonal changes in microbial contamination allows policymakers and water management authorities to develop more effective interventions, such as focused disinfection efforts and enhanced water treatment techniques, especially during periods of heightened risk.^[5] Furthermore, the study will contribute to the broader understanding of microbial pollution in water sources across Nigeria, providing a foundation for future research and policy development. Providing clean water access in Ikpoba Okha LGA is essential for reducing the occurrence of waterborne diseases and advancing Sustainable Development Goal 6, which highlights the importance of clean water and sanitation for everyone.

MATERIALS AND METHODS

Study area

Ikpoba Okha, a LGA in Edo State, Nigeria, lies between latitudes 6°15'N and 6°25'N and longitudes 5°30'E and 5°50'E. It forms part of the Benin metropolis and encompasses various towns and villages. The area experiences a tropical climate with distinct wet and dry seasons: the wet season spans from April to October, while the dry season lasts from November to March. Temperatures remain high throughout the year, ranging from 25°C to 32°C, with elevated humidity levels, particularly during the wet season. Ikpoba Okha's geography features a mix of lowlands, plateaus, river valleys, and estuarine areas. The southern part is characterized by low-lying plains, while the northern region predominantly includes the Edo Plateau. Several rivers, including the Ikpe, Ologbo, Ossiomo, Uteh, and Ikpoba rivers, traverse the LGA. Its drainage system comprises a network of channels, gutters, and stormwater drains. However, rapid urbanization and inadequate infrastructure have led to challenges such as flooding during heavy rainfall and natural drainage patterns. The vegetation in Ikpoba Okha varies by region. The southern part is dominated by tropical rainforests, while the central

and northern regions feature savanna woodlands. In addition, freshwater swamp forests and mangrove forests can be found in certain areas, contributing significantly to local ecosystems. Grasslands and farmlands are also widespread, supporting agricultural activities in the region.

Methods

The study employed survey and experimental designs to assess water quality across various sources in Ikpoba Okha LGA, Edo State. Water samples were collected from different sources during the rainy and dry seasons. Specifically, two samples each were taken from five rivers (Rivers Ikpe, Ologbo, Ossiomo, Uteh, and Ikpoba), five samples from wells, and eight samples from selected boreholes in eight communities: Evbuomodu, Uwusan, Obazagbon, Agedo, Evbumufi, Ekosa, Obadoloviyeyi, and Obenevbugo. These sources were chosen due to the prevalence of slum areas, inadequate toilet facilities, and the reliance on rivers for drinking water. Thirty-six water samples were collected using a simple random sampling method. For each sample, a clean 1.5-L plastic bottle was filled with water from a relatively undisturbed source after rinsing the bottle twice with the sample water. The bottle's mouth was positioned downstream to ensure proper sampling. Dissolved oxygen levels were fixed by adding two drops of Winkler's reagent to each sample. The samples were transported to the laboratory on the same day for analysis.

RESULTS

In Table 1, the water quality survey conducted in Ikpoba Okha LGA revealed that none of the borehole water samples tested positive for harmful bacteria. *E. coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Salmonella*, *V. cholerae*, *Proteus species*, and *Shigella* species were all negative across the tested samples. This indicates that the borehole water sources in the area are free from these pathogenic bacteria, suggesting a lower risk of waterborne diseases associated with these microorganisms.

Table 2 shows mixed results for well water quality in Ikpoba Okha LGA. *E. coli* tested positive in 6 out of 10 samples, *P. aeruginosa* was found in 5 out of 10 samples, and *S. aureus* was present in 6 out of 10 samples. Furthermore, 8 out of 10 samples were contaminated with *Salmonella*, 5 out of 10 with *V. cholerae*, 6 out of 10 with *Proteus* species, and 8 out of 10 with *Shigella* species. This indicates a significant level of microbial contamination in well water, with *Salmonella* and *Shigella* being the most prevalent pathogens.

Table 3 provides a seasonal breakdown of bacterial presence. *E. coli* was consistently present across most samples, particularly during the dry season. *P. aeruginosa* showed variability, with some samples testing negative. *S. aureus* was more prevalent in the rainy season, while *Salmonella* was present throughout the samples. *V. cholerae* appeared sporadically, with higher detection in the rainy season. *Proteus* spp. was more frequently detected during the dry season.

Table 1: Microbial analysis of borehole water during rainy and dry season at Ikpoba Local Government Area

Parameters analyzed	1R	2R	3R	4R	5R	6R	7R	8R	1D	2D	3D	4D	5D	6D	7D	8D	5B
<i>Escherichia coli</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Pseudomonas aeruginosa</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Staphylococcus aureus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Salmonella</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Vibrio cholerae</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Proteus sp.</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Shigella sp.</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Source: Fieldwork, 2024. -: Negative, R: Rainy season, D: Dry season, 1: Evbuomodun, 2: Uwasan, 3: Obazagbon, 4: Agedo, 5: Evbumufi, 6: Ekosa, 7: Obadoloviyeyi, and 8: Obenevbugo

Table 2: Microbial analysis of well water at Ikpoba Local Government Area, rainy and dry season

Parameters analyzed	A (R)	B (R)	C (R)	D (R)	E (R)	A (D)	B (D)	C (D)	D (D)	E (D)
<i>Escherichia coli</i>	+	-	-	+	-	+	-	+	+	+
<i>Pseudomonas aeruginosa</i>	-	+	-	+	+	-	+	-	-	+
<i>Staphylococcus aureus</i>	-	-	-	+	+	+	-	-	+	+
<i>Salmonella</i>	+	+	-	+	-	+	-	+	+	+
<i>Vibrio cholerae</i>	-	-	-	-	+	+	-	+	+	-
<i>Proteus sp.</i>	-	+	-	+	-	+	-	+	-	+
<i>Shigella sp.</i>	+	+	+	+	-	+	-	+	+	+

Source: Fieldwork, 2024. -: Negative, +: Positive, R: Rainy season, D: Dry season

Table 3: Microbial analysis of rivers at Ikpoba Local Government Area, rainy and dry season

Parameters analyzed	F (R)	G (R)	H (R)	I (R)	J (R)	F (D)	G (D)	H (D)	I (D)	J (D)
<i>Escherichia coli</i>	+	+	-	+	-	+	-	+	+	+
<i>Pseudomonas aeruginosa</i>	+	-	+	+	+	-	+	-	-	+
<i>Staphylococcus aureus</i>	-	+	+	+	+	+	-	-	+	+
<i>Salmonella</i>	+	+	-	+	-	+	-	+	+	+
<i>Vibrio cholerae</i>	-	+	-	-	+	+	-	+	+	-
<i>Proteus sp.</i>	-	+	-	+	-	+	+	+	+	+
<i>Shigella sp.</i>	+	+	+	+	-	+	-	+	+	+

-: Negative, +: Positive, R: Rainy season, D: Dry season

DISCUSSION

Tenebe et al.^[6] found that ten bacterial species were identified, with Gram-negative short-rod species such as *E. coli*, *Klebsiella pneumoniae*, and *Salmonella typhimurium* being predominant. Ekiameke et al.^[7] identified *E. coli* (16.6%) and *Staphylococcus spp.* (100%) in borehole water samples from Rivers State University hostels. In the South-South, Onuorah et al.^[8] explained that borehole water samples in Ogbaru communities were contaminated with *V. cholerae* and *Proteus* species, primarily due to flooding, which introduced nutrients and bacteria into the water, exacerbating pollution from sewage during the rainy season. This data indicates a concerning level of microbial contamination in the water sources of Ikpoba Okha LGA, with *Salmonella* and *Shigella* being the most frequently detected pathogens. The well water analysis from Ikpoba Okha LGA shows contamination by several pathogenic bacteria, including *E. coli*, *P. aeruginosa*, *S. aureus*, *Salmonella*, *V. cholerae*, *Proteus species*, and *Shigella* species. Studies across Nigeria report high levels of bacterial

contamination in water sources. Olalemi et al.^[9] estimated that the risks of infection associated with the pathogens in well water were greater than the acceptable risk limit of 10⁻⁴ and followed this order: Clostridium < Salmonella < Campylobacter < Shigella. Adeniran et al.^[10] Wemedo confirmed that sampled well waters in the South-South, Nigeria, exhibited significantly elevated levels of total aerobic heterotrophic bacteria (THB), total coliform bacteria, and fecal coliform bacteria, surpassing permissible limits for drinking water. The consistent presence of fecal coliforms indicated fecal contamination, while high THB levels suggested organic pollution. In addition, the isolation of pathogenic bacteria, including *Salmonella* species, confirmed the organic contamination of these water sources. Obikpo et al.^[11] found that well water in Abakpa, Obiagu, and Achara layouts showed significant contamination, with mean total bacterial counts of 0.8825, 0.8435, and 0.8384 × 10⁴ cfu/ml, respectively. Total coliform counts averaged 5.15, 5.45, and 5.05 mpn/100 ml, while fecal coliform counts were 2.4, 2.65, and 2.05 mpn/100 ml. A total of 50 pathogenic

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