Studies on the Public Health Risks of the Urban Water System in Port Harcourt, Rivers State

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Abstract
This study examines the public health risks associated with urban water systems in Port Harcourt, Rivers State, Nigeria, with a focus on sanitation sources and the quality of borehole drinking water. It assessed water contamination in recreational swimming areas, flood zones, fecal sites, and open drains, as well as borehole water quality. Data collection involved field surveys, lab tests, and interviews with local health officials, with descriptive statistics used for analysis. The laboratory findings revealed a variety of microbial and parasitic contaminants, such as *Cryptosporidium*, *Giardia lamblia*, *Entamoeba*, *Escherichia coli*, and *Klebsiella pneumoniae*. The most significant levels of pathogens were found in flood and fecal sites, while swimming areas were heavily tainted with *Cryptosporidium* and *Giardia*. Borehole samples also showed the presence of *Microsporidia*, *Cryptosporidium parvum*, and concerningly high levels of Total Suspended Solids and iron, exceeding WHO standards. Many residents rely on untreated borehole water, and survey results indicated a lack of awareness about water treatment. This study highlights the pressing need for improved sanitation infrastructure, better regulation of boreholes, and increased public education on water.

Keywords: Urban Water Systems, Waterborne Diseases, Public Health Risks, Port Harcourt

Introduction

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Urban water systems (UWS) play a crucial role in ensuring public health and promoting sustainability in our cities. In fast-growing urban areas like Port Harcourt, Rivers State, these systems consist of a complicated web of both drinking and non-drinking water sources, such as boreholes, surface drains, floodwaters, sanitation channels, and even recreational waters. Unfortunately, these systems are facing mounting challenges due to population growth, aging infrastructure, and a lack of proper regulatory oversight. This study aims to delve into the public health risks tied to these systems, with a particular *emphasis on borehole water, which is the main source of drinking water for most residents (Jinadu* et *al.*, 2024; Okeke *et al*., 2024).

Despite some efforts by local authorities, Port Harcourt still grapples with serious issues regarding water quality and safety. One major concern is the inadequate protection of water infrastructure—things like poorly sealed boreholes, illegal waste being dumped into open drains, and flood-prone areas all contribute to the risk of biological contaminants, including bacteria, helminths, and protozoa (Bello *et al*., 2025; Eze & Nwankwo, 2025). These risks become even more pronounced during the rainy season, when storm water runoff creates more pathways for waterborne pathogens (Owolabi *et al*., 2024).

According to the Federal Ministry of Water Resources (2024), over 55% of urban households in Nigeria rely on borehole water, yet more than 70% of these systems operate without any formal regulation. This lack of

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oversight allows for the spread of microbial contamination. Recent research has found pathogens like *Giardia lamblia*, *Cryptosporidium parvum*, *Escherichia col*i, and *Leptospira* spp. in both drinking and recreational waters in cities like Lagos and Port Harcourt (Adewale *et al*., 2024; Eze & Amadi, 2025). Additionally, epidemiological data indicate a worrying rise in gastrointestinal illnesses linked to untreated borehole water (Bello *et al.*, 2025).:

The lack of public awareness about water treatment methods adds to health risks. While there are straightforward household disinfection techniques like boiling, filtration, and chlorination, not many people are using them, only about 31% of residents treat borehole water before using it (Hassan *et al*., 2025; Rivers State Ministry of Health, 2024). The problem is made worse by the widespread practice of open defecation, especially in unregulated areas, which compromises the integrity of water sources (Nwosu & Eze, 2025; Umar *et a*l., 2025).

Given the complexity of these issues, this study aims to evaluate the health risks associated with urban water systems in Port Harcourt, pinpoint key microbial contaminants and how people are exposed to them, and look into public attitudes towards water treatment. The goal is to provide insights that can lead to data-driven interventions and improve urban water governance.

Literature Review

The increasing prevalence of waterborne diseases in developing urban areas has become a significant topic in global health discussions. The Global Burden of Disease Report (Lopez *et al.*, 2006) highlights that water-related infections lead to over 1.8 million deaths each year, with low-income countries like Nigeria bearing the brunt. Factors like poor sanitation, informal housing, and unregulated water sources leave urban populations especially susceptible to contamination (USAID, 2002; Müller *et al.*, 2023).

Port Harcourt is a prime example of this issue. Numerous studies have shown the presence of harmful microorganisms in both drinking and recreational water sources. For instance, Chukwu *et al.* (2024) found a significant amount of E. coli and Klebsiella spp. in urban wastewater from informal settlements in Nigeria. Likewise, Ibrahim *et al.* (2024) discovered helminthic ova in untreated water sources in southwestern cities. These pathogens often enter the water supply through fecal runoff, septic system failures, or contact with floodwater, posing serious health risks in urban slums (Kabiru *et al*., 2024; Valcarel, 2000).:

Protozoan pathogens are particularly worrisome because they can cause infections with just a tiny number of organisms. For instance, *Giardia lamblia* and *Cryptosporidium parvum* only need a few cysts to trigger an infection, which makes them a real threat even in situations where contamination seems low (Adewale *et al.*, 2024; Eze & Nwankwo, 2025). Their presence in swimming pools and recreational areas is also a concern, adding a layer of risk that often gets overlooked in public health strategies (Hamil & Bell, 1986; Adewale *et al.*, 2024).

In Nigeria, water quality testing typically follows guidelines set by Ademoroti (1986) and Franson (1995). However, the actual implementation can be hit or miss due to budget issues and a lack of technical know-how. In Port Harcourt, the situation is even trickier because of inconsistent water treatment and aging infrastructure. Onyema *et al*. (2024) have pointed out that using UV and ozone disinfection technologies could greatly cut down on microbial contamination in urban drinking water systems, but unfortunately, these advancements are mostly stuck in the pilot phase.

Borehole water is commonly used, but it often doesn't have the safety measures it needs. Research by Jinadu *et al*. (2024) and Okeke *et al*. (2024) indicates that borehole water in Lagos and Port Harcourt frequently falls short of the WHO (2025) microbial quality standards. Issues like poor site selection, unsealed headworks, and a lack of regular testing all contribute to contamination. Additionally, public awareness about preventing waterborne diseases is quite limited, with many households

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relying on how clear the water looks instead of scientific testing to judge its quality (Hassan *et al.*, 2025).

Flooding is a seasonal issue that significantly increases risks. As noted by Owolabi et al. (2024), floodwaters often mix with open drains and latrine waste, leading to contamination of nearby boreholes and water storage systems. This results in periodic spikes in diarrheal diseases and outbreaks of leptospirosis during the rainy season (Eze & Amadi, 2025).

Regulatory frameworks are still quite weak. While the revised National Water Resources Bill (2023) sets out standards for water safety, many Nigerian states struggle with enforcement due to underdeveloped or underfunded mechanisms (Umar *et al.*, 2025). This lack of oversight has allowed unregistered boreholes and informal water vendors to flourish, often without any accountability for water safety (Nwosu & Eze, 2025; Kabiru *et al.*, 2024).

In conclusion, both international and local studies highlight a significant connection between urban water mismanagement and the public health crisis in Nigerian cities. The evidence points to the urgent need for better infrastructure, stronger governance, and focused community education. To create effective and sustainable water safety interventions in Port Harcourt, it's crucial to have a thorough understanding of local microbial risks and behavior patterns.

Study area/population

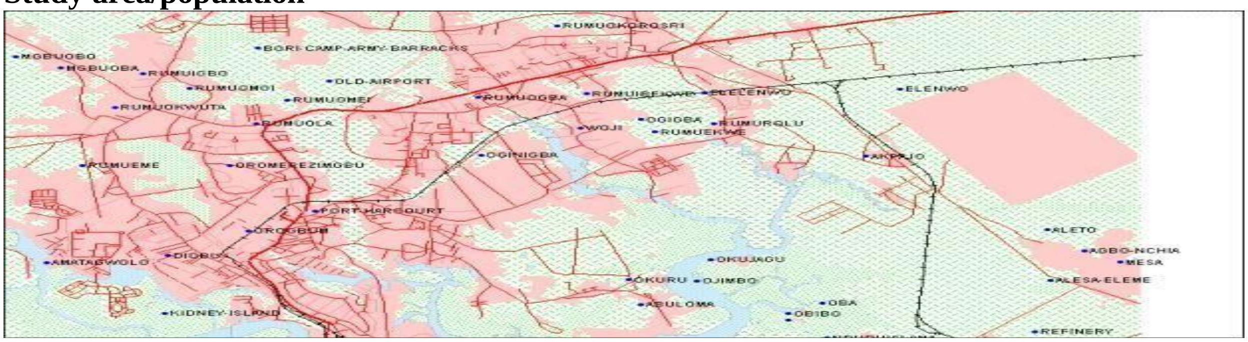

Figure 1: Location of Port Harcourt
CIA World Factbook 2003.

The research took place in Port Harcourt, the capital of Rivers State (see Figure 1). Nestled about 41 miles (66 km) upstream from the Gulf of Guinea, Port Harcourt is located in southern Nigeria along the Bonny River, which is an eastern tributary of the Niger River. The city, named after colonial secretary Lewis Harcourt, was founded in 1912 in a region that has long been home to the Ijaw people.

Port Harcourt enjoys a dry equatorial climate and spans an area of 17,362 hectares. The city sees an average annual rainfall of 810 mm, with temperatures typically ranging from 24°C in August to 27°C in March, making it hot and humid.

While Port Harcourt has a solid network of primary drainage systems throughout the metropolitan area, issues like poor maintenance, careless waste disposal, and inadequate development control have led to significant flooding, siltation, and pollution in various neighborhoods. As of the 1996 National Census estimate, the population stands at 1,148,665, with a growth rate of 3.05%. Geographically, Port Harcourt is positioned at 4.77742°N latitude and 7.0134°E longitude, with an average elevation of 468 meters above sea level. The region is marked by coastal savannah vegetation and faces severe erosion challenges due to its closeness to the continental shelf, strong coastal currents, and wind action.

Methodology

This study explored the public health risks linked to the urban water system in Port Harcourt, Rivers State, concentrating on two primary pathways: sanitation-related water sources and borehole drinking water.

Study Area and Sampling

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water samples were collected from key urban spots like Agip, Diobu, and Rumukalagbor/Elekahia to capture a range of population exposures to different water sources.The sampling included recreational swimming areas, flood-prone zones, open drainage channels, and bodies of water used for sanitation. To get a clearer picture of waterborne diseases, interviews were conducted with staff from the Rivers State Ministry of Health and local clinics.The primary data collection was complemented our with secondary epidemiological data.

For the borehole water pathway, field observations was carried out to evaluate vulnerability and contamination risks at borehole sites. Structured questionnaires were distributed and interviews conducted with residents living within a 0.5 km radius of each borehole, which aligns with typical service areas (Hamil & Bell, 1986). Out of 1200 questionnaires sent out across the three study areas, 1154 were completed and returned, giving us valuable quantitative insights into borehole water usage and the health risks associated with it.

Water Quality Analysis

In the lab, we analyzed borehole water samples for essential physicochemical and microbiological parameters. Dissolved oxygen (DO) and biological oxygen demand (BOD) were measured using the Winkler and iodometric methods, respectively, following USEPA protocols (1986). To determine heavy metal concentrations, samples were digested with concentrated nitric acid (HNO_3) and analyzed them using an atomic absorption spectrophotometer (AAS, 210VGP model). Additional parameters like pH, temperature, electrical conductivity, and ion content were also measured using standard methods (Ademoroti, 1986; Franson, 1995).

To ensure quality assurance and control, standard solutions, procedural blanks were utilized and triplicate analyses was conducted (Valcarel, 2000).

Data Analysis

Descriptive statistics, including simple percentages and mathematical expressions, were used to analyze survey data. Laboratory water quality results were integrated with survey findings to provide a comprehensive assessment of public health risks associated with Port Harcourt's urban water system. Secondary data sources included government reports, scientific journals, and textbooks, which provided historical context and supported the interpretation of primary data.

Results on Sanitation Pathways

Recreational Swimming

Table 1: Occurrence of Organisms in Recreational/Swimming Sites

Toxin Protozoa	**Site 1 (Agip Area)**	**Site 2 (Diobu Area)**	**Site 3 (Rumukalagbor/Elekahia Area)**
***Cryptosporidium* spp**	+	+	+
Giardia lamblia	+	-	+
***Entamoeba* spp**	+	+	+

Note: + = Identified
-= Not Identified

Site 1: Agip Area Recreational Swimming Water, Site 2: Diobu Recreational Swimming Water, Site 3: Rumukalagbor/Elekahia Recreational Swimming Water

The presence of microorganisms at the recreational swimming sites in the study area is summarized in Table 1. The analysis of the recreational swimming sites revealed the presence of three protozoan species: *Cryptosporidium spp.*, *Giardia lamblia*, and

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Entamoeba spp. All protozoans were present in most of the sites, except for *Giardia lamblia*, which was absent in Diobu. No helminth eggs or adult worms were identified at any of the recreational swimming sites.

Flood/Faecal Sites

Table 2: Organisms Identified in Flood/Faecal Sites

Toxin Protozoa	Site 4 (Agip Flood/Faecal)	Site 5 (Diobu Flood/Faecal)	Site 6 (Rumukalagbor/Elekahia Flood/Faecal)
Cryptosporidium spp	+	+	+
Euglena spp	-	+	-
Vorticella spp	-	+	+
Giardia lamblia	+	+	+
Entamoeba spp	+	+	+
Stentor spp	-	+	+
Paramecium spp	+	+	+
Helminths			
Necator americanus	-	+	-
Ascaris spp	-	+	+

Note: + = Identifiedl - = Not identified, Site 4: Agip Flooding/Faecal Site, Site 5: Diobu Flood/Faecal Site, Site 6: Rumukalagbor/Elekahia Flooding/Faecal Site.

The occurrence of organisms at the flood/fecal sites is presented in Table 2. At the flood/fecal sites, *Cryptosporidium spp.*, *Giardia lamblia*, *Entamoeba spp.*, and *Paramecium spp.* were consistently present across all sites. *Vorticella spp.* and *Stentor spp.*, ciliated protozoans, were found only in Diobu and Rumukalagbor/Elekahia sites but were absent in Agip. The *Euglena spp.* was present only in Diobu. *Necator americanus* eggs were found in Diobu, while *Ascaris spp.* Eggs were detected in both Diobu and Rumukalagbor/Elekahia, but not in Agip.

Open Drainage

The occurrence of organisms in open drainage systems is summarized in Table 3. In the open drainage systems, the pathogenic protozoa *Cryptosporidium spp.*, *Euglena spp.*, and *Vorticella spp.* were identified across all sites. *Giardia lamblia* was absent in Agip and Diobu but present in Rumukalagbor/Elekahia. *Entamoeba spp.* was found only in Diobu. *Paramecium spp.* was observed in Agip and Rumukalagbor/Elekahia, but not in Diobu. No helminth parasites were detected in the samples from any of the open drainage sites.

Table 3: Organisms Identified in Open Drainage Sites

Toxin Protozoa	Site 7 (Agip Open Drainage)	Site 8 (Diobu Open Drainage)	Site 9 (Rumukalagbor/Elekahia Open Drainage)
***Cryptosporidium* spp**	+	+	+
***Euglena* spp**	+	+	+
***Vorticella* spp**	+	+	+
Giardia lamblia	-	-	+
***Entamoeba* spp**	-	+	-
***Paramecium* spp**	+	-	+

Note: + = Identified ; - = Not Identified

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Site 7: Agip Open Drainage, Site 8: Diobu Open Drainage, Site 9: Rumukalagbor/Elekahia Open Drainage

Surface Water Total Heterotrophic Bacteria (THB)

Table 4: The distribution of Bacterial Isolates

Bacterial Isolate	*ARSW*	*DRSW*	*RERSW*	*AFFS*	*DFFS*	*REFFS*	*AOD*	*DOD*	*REOD*
Klebsiella pneumoniae	-	-	-	+	+	+	+	+	+
Pseudomonas aeruginosa	+	+	+	+	+	+	+	+	+
Escherichia coli	+	+	+	+	+	+	+	+	+
Serratia marcescens	-	-	-	-	-	-	+	+	+
Staphylococcus aureus	-	-	-	+	+	+	-	-	-
Bacillus spp.	-	-	-	+	+	+	+	+	+
Shigella spp.	+	+	+	-	-	-	-	-	-
Achromobacter	-	-	-	-	-	-	+	+	+
Enterobacter spp.	-	-	-	+	+	+	-	-	-
Micrococcus spp.	-	-	-	+	+	+	-	-	-
Acinetobacter spp.	-	-	-	+	+	+	-	-	-

Note: + = Identified
= Not Identified
ARSW = Agip Area Recreational Swimming Water, DRSW = Diobu Recreational Swimming Water
RERSW = Rumukalagbor/Elekahia Recreational Swimming Water, AFFS = Agip Flooding/Faecal Site
DFFS = Diobu Flood/Faecal Site, REFFS = Rumukalagbor/Elekahia Flooding/Faecal Site
AOD = Agip Open Drainage, DOD = Diobu Open Drainage, REOD = Rumukalagbor/Elekahia Open Drainage

Table 4 shows the distribution of Bacterial Isolates, Eleven bacterial species were identified across the sampled sites, including Klebsiella pneumoniae, Pseudomonas aeruginosa, Escherichia coli, Serratia marcescens, Staphylococcus aureus, Bacillus spp., Shigella spp., Achromobacter spp., Enterobacter spp., Micrococcus spp., and Acinetobacter spp.

The percentage occurrence of bacterial species varied across the sites. Recreational swimming sites (ARSW, DRSW, RERSW) recorded 27.27% of the identified bacteria species, while flood/fecal sites (AFFS, DFFS, REFFS) showed 72.72% presence, and open drainage sites (AOD, DOD, REOD) revealed 45.45% of bacterial species.

Microbial and Parasitic Contamination in Borehole Water Samples

Table 5: Presence of Organisms in Borehole Water Samples

Organisms	Agip	Diobu	Rumukalagbor/ Elekahia
Microsporidia	+	+	-
Cyclospora cayetanensis	+	+	-
Cryptosporidium parvum	-	+	+
Sarcocystis	+	+	+
Rotifer	+	+	+
Charcot-Leyden Crystals	-	+	+
Artifact	+	+	+

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(Each organism is represented by its occurrence across different samples from the study sites.)

+ = Identified
= Not Identified

Table 5 shows the presence of organisms in borehole water samples. The microbial analysis of borehole water samples from the study sites (Agip, Diobu, and Rumukalagbor/Elekahia) revealed the presence of various organisms, including *Microsporidia*, *Cyclospora cayetanensis*, *Cryptosporidium parvum*, *Sarcocystis*, and Rotifers. Additionally, Charcot-Leyden crystals and several artifacts were observed. Table 3.8 outlines the occurrence of pathogenic and non-pathogenic organisms in water samples, recorded as the number of organisms per 10µl of deposit from each borehole water sample.
Parasitic Load Analysis:

The parasitic load across the samples showed substantial variation. Of the total samples analyzed, 29.6% contained at least one type of parasite, 14.8% contained two types, 25.9% contained three types, and 29.6% had four types. The most common organism found was *Microsporidia*, present in 14 out of 27 samples (52%). The samples containing *Microsporidia* were frequently co-contaminated with *Cyclospora*. In samples with *Cryptosporidium*, *Sarcocystis* was the second most common contaminant. Over 5% of the samples had a noticeable slimy texture and emitted an objectionable odor, suggesting a higher level of contamination.

Physicochemical Analysis of Borehole Water Samples
Table 6: Physicochemical Analysis of Borehole Water Samples

Parameter	Agip Area 2	Diobu	Rumukalagbor/Elekahia	WHO Limits
pH	4.31	3.61	3.87	6.0 - 8.5
Odor	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
Color	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
BOD5 (mg/l)	2.16	3.81	2.51	10
COD (mg/l)	3.60	6.38	4.20	10
DO (mg/l)	5.02	3.11	4.99	10
TSS (mg/l)	2.10	2.50	0.55	<1.0
Conductivity (µS/cm)	307.00	551.00	70.00	-
TDS (mg/l)	141.00	276.00	32.00	500
Salinity (mg/l)	13.00	26.00	3.00	200
Turbidity (NTU)	4.50	4.10	4.50	5.0
Lead (mg/l)	<0.001	<0.001	<0.001	Nil
Zinc (mg/l)	<0.001	<0.009	<0.001	5.0
Total Iron (mg/l)	0.023	0.031	<0.001	0.020
Copper (mg/l)	0.011	0.009	0.017	0.05
Chromium (mg/l)	<0.001	<0.001	<0.001	0.03

Table 6 presents the results of the physicochemical analysis conducted on borehole water samples collected from the Agip, Diobu, and Rumukalagbor/Elekahia areas. The analysis evaluates a range of parameters to assess the water quality and compliance with the World Health Organization (WHO) guidelines for safe drinking water.
The results from the physicochemical analysis show that all parameters assessed were within the WHO limits, except for Total Suspended Solids (TSS) and Total Iron. The WHO

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standard for TSS is set at less than 1.0 mg/l. However, the Agip and Diobu samples exceeded this limit with TSS concentrations of 2.10 mg/l and 2.50 mg/l, respectively. The Rumukalagbor/Elekahia sample had a TSS value of 0.55 mg/l, which is within the acceptable range for domestic water. The WHO limit for total iron is 0.020 mg/l. Diobu had the highest concentration of iron at 0.031 mg/l, followed by Agip with 0.023 mg/l. The Rumukalagbor/Elekahia sample had no detectable iron (<0.001 mg/l) The conductivity values varied across the areas, with the highest recorded in Diobu (551.00 µS/cm) and the lowest in Rumukalagbor/Elekahia (70.00 µS/cm). However, no WHO guideline limit for conductivity was specified in the table.

Questionnaire Data Analysis and Results

A total of 1000 completed questionnaires out of the 1200 distributed were used for the analysis. Each questionnaire contained 12 items, grouped according to their relevance to the research questions. The data was analyzed using percentages, means, and standard deviations to provide insights into the respondents' perceptions of water, sanitation, and quality.

Table 7: Demographic Characteristics of the Sample Population

Demographic Characteristic	Number Sampled	Percentage (%)
Sex		
Male	**404**	**40.4**
Female	**596**	**59.6**
Marital Status		
Single	**611**	**61.1**
Married	**389**	**38.9**
Age Group		
Below 20 years	**470**	**47.0**
21 – 45 years	**384**	**38.4**
46 – 65 years	**146**	**14.6**
66 years and above	**-**	**-**
Occupation		
Student	**484**	**48.4**
Civil Servant/Company Worker	**283**	**28.3**
Trader/Farmer	**195**	**19.5**
Other	**38**	**3.8**
Academic Level		
No Formal Education	**62**	**6.2**
Primary/Secondary Education	**492**	**49.2**
Diploma/Degree	**227**	**22.7**
Postgraduate	**219**	**21.9**

The demographic analysis of the sample population revealed that 59.6% of respondents were female, while 40.4% were male. The largest age group was those below 20 years (47%), followed by those aged 21 – 45 years (38.4%). A majority of the respondents were single (61.1%), while 38.9% were married. Most respondents were students (48.4%), followed by civil servants/company workers (28.3%) and traders/farmers (19.5%). Regarding education, 49.2% of respondents had primary/secondary education, 22.7% had a diploma or degree, and 21.9% had postgraduate qualifications.

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Table 8: Response of Respondents on Water and Sanitation Pathway

Item	SA	A	U	D	SD	Total	Mean	SD
Washing and domestic activities are done at recreational swimming places.	206	570	116	78	30	1000	3.8	0.94
Local wood toilets near water sides with fecal excretions flowing to swimming places.	352	627	3	11	7	1000	4.3	0.61
Children often play in flooded streets during the flooding period.	195	456	186	102	61	1000	3.6	1.09
Feces from soak-away toilets are discharged into flood drains/water bodies.	99	481	399	17	4	1000	3.7	0.68
Insects transmit diseases from open gutters to humans.	92	228	396	198	113	1000	3.1	1.12
Children fall into open gutters when playing around them.	283	671	12	32	2	1000	4.2	0.63

Key: SA= Strongly Agree, A=Agree, U=Undecided (or Neutral), D=Disagree, SD= Strongly Disagree

Table 8 illustrates the responses of respondents on the water and sanitation pathway. The result shows that the mean scores for various questions on water and sanitation ranged from 3.1 to 4.3, indicating general agreement on the sanitation concerns raised. The highest mean was 4.3 for the item regarding the proximity of local wood toilets to water bodies, with a standard deviation of 0.61, suggesting strong agreement among respondents. The lowest mean of 3.1 was recorded for the item about insects transmitting diseases from open gutters, with a higher standard deviation of 1.12, indicating more variability in responses.

Table 9: Response of Respondents on Borehole/Drinking Water Pathway

Item	SA	A	U	D	SD	Total	Mean	SD
A major source of drinking water in Port Harcourt is borehole water.	129	561	51	197		1000	3.5	1.13
Borehole owners often treat water and clean storage tanks.	2	38	481	294		1000	2.4	0.83
Children often collect drinking water for the household.	289	533	57	69		1000	3.9	1.04
The age range of children collecting drinking water is 7-20 years.	114	781	9	64	32	1000	3.9	0.86
People prefer borehole water due to its affordability.	95	889	7	9	0	1000	4.1	0.37
At home, people drink borehole water directly without boiling, filtering, or settling.	293	483	212	11		1000	4.1	0.75

Key: SA= Strongly Agree, A=Agree, U=Undecided (or Neutral), D=Disagree, SD= Strongly Disagree

Table 9 reveals the responses of respondents on the borehole/drinking water pathway. The responses regarding the use of borehole water indicate a strong preference for borehole water as a primary drinking source, with a mean of 4.1 for items about its affordability and the habit of drinking it untreated. The highest mean for an individual item, 4.1, was recorded for questions concerning water usage practices. However, the item about treating the water before use had a lower mean of 2.4, suggesting that a significant portion of respondents do not regularly treat borehole water.

DISCUSSION

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This study took a close look at the public health risks tied to Port Harcourt's urban water system (UWS), zeroing in on how people are exposed to contaminated drinking and recreational waters. With rapid urban growth putting immense pressure on water infrastructure in Nigerian cities, the already tough job of keeping water and wastewater systems safe has become even more complicated (Okeke *et al*., 2024). Port Harcourt stands out as a key example of how a lack of proper water treatment facilities heightens the risk of waterborne diseases, particularly in communities that mainly depend on borehole water for their daily needs (Nwosu & Eze, 2025).

The findings from this study make it clear that seasonal flooding during the rainy season worsens contamination levels in water sources, significantly raising health risks for residents (Owolabi *et al*., 2024). Floodwaters often mix with sewage, surface runoff, and other pollutants, spreading harmful microorganisms throughout the urban water system. This pattern of contamination highlights the broader issues faced by rapidly growing urban areas, where outdated and inadequate sanitation facilities struggle to keep up with the needs of expanding populations (WHO, 2025). The direct effects of flooding on water quality emphasize the urgent need for thorough urban planning and better drainage systems.

Recreational and drainage waters have consistently shown contamination with fecal pathogens like *Cryptosporidium* spp., *Giardia lamblia*, and *Entamoeba* spp. This backs up previous studies that point to inadequate sanitation practices, open defecation, and poor waste management as major contributors to the heightened risk of exposure to waterborne protozoa (Adewale *et al*., 2024). These harmful protozoans are linked to a significant number of gastrointestinal illnesses in the area, leading to serious health issues such as chronic diarrhea and dehydration (Bello *et al.*, 2025). To tackle the spread of these infections and lessen the overall disease burden in urban populations, it's essential to enhance sanitation infrastructure and wastewater treatment processes (Müller *et al*., 2023).

Pathogenic bacteria, including Escherichia coli, *Salmonella* spp., and *Leptospira* spp., were often found near sewage discharge points, particularly in informal settlements, highlighting the widespread sanitation issues in urban Nigeria (Chukwu *et a*l., 2024). The health risks from this bacterial contamination are worsened by inadequate wastewater treatment, resulting in frequent outbreaks of diarrheal diseases and leptospirosis, which pose a significant threat to vulnerable groups like children and the elderly (Eze & Amadi, 2025). Additionally, protozoan pathogens are increasingly recognized for their resistance to traditional disinfection methods such as chlorination, underscoring the urgent need for advanced water treatment technologies like ultraviolet (UV) irradiation and ozonation to ensure the safety of urban drinking water (Onyema *et al*., 2024).

Although helminthic parasites weren't detected in this study, their presence in other urban areas of Nigeria raises concerns about potential future risks if sanitation and wastewater systems aren't improved (Ibrahim et al., 2024). Therefore, ongoing monitoring for helminthic infections is recommended to proactively address these risks.
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While many people think of borehole water as a safer choice compared to surface water, this study uncovered some alarming contamination issues with pathogens like *Microsporidia*, *Giardia lamblia*, and *Cryptosporidium parvum*. The presence of *Microsporidia*, a tough protozoan that can withstand standard water treatment methods, highlights serious weaknesses in the safety of borehole water (Eze & Nwankwo, 2025). These results add to a growing pile of evidence showing that poorly managed borehole water sources in various African cities are turning into significant health risks (Jinadu *et al*., 2024). In Port Harcourt, factors leading to borehole contamination include shoddy construction practices,

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insufficient filtration, and the dangerous closeness of boreholes to sewage systems. On top of that, neglecting the upkeep of storage tanks—like using open or poorly covered containers—only heightens the risk of contamination by letting insects and environmental pollutants get into the drinking water (WHO, 2025).

Drinking untreated borehole water can be dangerous for our health, especially for those who are more vulnerable, like kids, the elderly, and anyone with a weakened immune system. Infections from *Giardia* and *Cryptosporidium* can lead to serious issues like severe dehydration, long-lasting diarrhea, malnutrition, and, in the worst cases, even death (Müller *et al*., 2023). To tackle this, public health initiatives that promote household water filtration, safe water handling, and effective purification technologies are crucial. These steps can help lower the rates of these diseases and boost overall health in the community (Adewale *et al*., 2024).

During the study, we found that there's a big gap in what people know about the health risks of drinking untreated or poorly treated water. This shows just how important it is to launch community education campaigns that raise awareness about waterborne diseases and encourage safer drinking habits (Okeke *et al*., 2024). By empowering residents with knowledge about proper water treatment and safe handling, we can significantly cut down on waterborne illnesses in urban areas (Hassan *et al.*, 2025). Plus, developing and expanding community-level water filtration programs can be key to providing safe drinking water for low-income families, helping to bridge the health disparities tied to water quality (Kabiru *et al.*, 2024).

Finally, there is a critical need to strengthen water quality regulations and enforcement mechanisms in Nigeria. The government really needs to focus on reviewing and improving water safety standards, making sure that both borehole and sanitation water sources align with internationally recognized safe drinking water criteria. A solid regulatory framework should involve regular water quality monitoring, building the capacity of regulatory agencies, and taking corrective actions whenever non-compliance is found (Umar et al., 2025). To sustainably meet the growing demand for safe and reliable urban water supplies, especially with the pressures of population growth and urbanization, we also need to invest in water infrastructure and actively engage and educate the community.

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