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Adam, S. M.

College of Education Waka-Biu, Borno State, Nigeria.

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The Evaluation of Anthropogenic Activities and Domestic Waste on Surface Water Quality in Borno State

Adam, S. M.

College of Education Waka-Biu, Borno State, Nigeria.

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Abstract

This study assessed the primary sources of drinking water, household water treatment practices, and the impact of anthropogenic activities on surface water quality and public health across Biu, Konduga, and Maiduguri Local Government Areas (LGAs) in Borno State, Nigeria. The findings revealed that boreholes, rivers/streams, and sachet water are the major sources of household water. However, reliability varied, with many households reporting seasonal shortages and irregular access. While some households practiced boiling, filtration, or the use of chlorine tablets, a significant proportion relied on untreated water, thereby increasing exposure to waterborne diseases. Anthropogenic activities including indiscriminate waste disposal, open defecation, and dumping of domestic refuse were identified as key contributors to surface water contamination. Laboratory analysis of water samples confirmed elevated microbial counts and the presence of coliform bacteria, indicating fecal contamination. These conditions pose significant risks of cholera, diarrhea, typhoid, and other waterborne infections. The study concludes that improving water supply infrastructure, strengthening sanitation practices, and promoting affordable household treatment technologies are critical to safeguarding public health. The research underscores the urgent need for community-based water management strategies and enforcement of environmental health regulations in Borno State.

Keywords: Surface water quality, Anthropogenic activities, Domestic waste, Water pollution, Public health, Borno State, Nigeria.

For corresponding author:
E-mail: *info@esxpublishers.com*
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Introduction

Anthropogenic activities and dumping of waste on the river bank also results to the contamination of surface water quality, water may of these micro-organisms when present in large quantities and for prolonged period of time can cause health problem (WHO, 2018). There is a strong relationship existing between water, health and diseases causation (Ajewole, 2017). Water is a very essential element of human nature, yet a very dangerous element in the spread of diseases.

Water is vital for human survival and serves multiple functions beyond drinking and household use. It plays a crucial role in transportation, waste management, agriculture, and the generation of hydroelectric power. Covering about 80% of the Earth's surface, water exists in both natural and artificial forms. Natural sources include atmospheric water (rain, hail, and snow), surface water (rivers, lakes, streams, and oceans), and groundwater (wells, springs, and underground streams). Artificial sources consist of human-made reservoirs such as dams, ponds, and dug wells. Surface water is easily exposed to contamination, as it can collect impurities such as dust, smoke, gases, and pathogenic organisms from the atmosphere.

According to a recent study, surface water is a contributing factor in both water-borne and water-related illnesses (Medema, 2016). Potable water is defined as water that is free of chemicals that are harmful to health and microorganisms that cause disease. Based on where they come from, surface water pollution sources can be divided into two groups: point sources and non-point sources. Point source pollution is the term for pollutants that enter a waterway through a separate conveyance, like a pipe or ditch. Diffuse contamination that does not come from a single, distinct source is known as nonpoint pollution. Non-point source pollution results from the accumulation of small amounts of contaminants collected over a wide area (USGS, 2019).

Sewage and sewage effluents have been identified as major contributors to water contamination. Surface water is widely recognized as containing higher concentrations of harmful microorganisms compared to other sources such as groundwater and rainwater (Oyebode, 2018). The frequent discharge of sewage and domestic wastewater introduces bacteria and other disease-causing organisms that pose health risks to both humans and animals, including livestock. Other notable sources of contamination include livestock waste, municipal effluents, wastewater from schools and feedlots, as well as runoff from swampy regions.

Waterborne diseases remain a significant source of public health risks. Due to the increasing demand for water and the growing levels of contamination, it is crucial to conduct regular assessments of water quality (WHO, 2015; EPA, 2017). Evaluating the physical, chemical, and biological characteristics of water sources is necessary to determine their suitability and safety for human consumption.

Statement of the Problem

In recent decades, the quality of drinking water has deteriorated, primarily due to the release of wastewater into natural water bodies and contamination from environmental pollutants (Liu and Jones, 2020). The high microbial levels often detected in these waters are largely influenced by human activities and uncontrolled waste disposal, which introduce pollutants into streams and promote microbial proliferation. The common bacterial and fungal organisms likely to be identified include *Escherichia coli*, *Enterobacter* species, *Staphylococcus aureus*, *Streptococcus* species, *Bacillus* species, *Proteus* species, *Lactobacillus* species, *Pseudomonas aeruginosa*, *Saccharomyces* species, *Kluyveromyces* species, and *Aspergillus* species. These microorganisms have been linked to various gastrointestinal infections, including diarrhea, as well as upper respiratory tract infections and related health complications (Prescott *et al.*, 2020).

The presence of indicator bacteria such as *Escherichia coli* and *Enterobacter* species in drinking water is unacceptable, as it signifies fecal contamination of the water body and indicates the likely presence of other disease-causing enteric pathogens. This represents a serious public health issue, requiring prompt intervention in contaminated water sources. Additionally, *Escherichia coli* is a well-known causative agent of several gastrointestinal illnesses, including traveler's diarrhea and other diarrheal conditions (Pandey *et al.*, 2016).

Mosquitoes, snails, fish, and edible plants are identified as potential vectors of waterborne pathogens (Victor, 2018; Szewzyk *et al.*, 2018). *Staphylococcus aureus*, a normal commensal organism of the skin and mucous membranes, is the primary etiological agent of septic arthritis (Ellen and Sydney, 2020; Eze *et al.*, 2017). Additionally, consumers face the risk of foodborne illnesses, as *S. aureus* is a major causative agent of staphylococcal food poisoning, which is commonly characterized by symptoms such as diarrhea and vomiting (Singleton, 2019; Frazier and Westhoff, 2022; Eze *et al.*, 2017).

Bacillus species are gram-positive, aerobic, spore-forming bacteria. Many members of this genus are saprophytic, commonly inhabiting soil, air, and vegetation, which accounts for their detection in river water (Thomas, 2022; Brooks *et al.,* 2020; Abdo, 2018; Eze *et al.,* 2017). The occurrence of opportunistic pathogens such as *Proteus* species, *Lactobacillus* species, and *Pseudomonas aeruginosa* in the river is likely linked to contamination from immunocompromised individuals who bathe in the water.

Significant financial investments and policy efforts from various stakeholders have increasingly been directed toward addressing waterborne diseases. This heightened concern is largely linked to the persistent insurgency in northeastern Nigeria, particularly in Borno States, which has severely affected the socioeconomic conditions of the local population. Most residents depend on subsistence farming and livestock rearing; however, insecurity has disrupted these livelihoods, forcing many to rely on nearby water bodies for survival.

Furthermore, untreated waste from multiple sources is often discharged into these water bodies, creating breeding grounds for vectors and aquatic pathogens. This contamination threatens the health of humans, livestock, and aquatic organisms. Consequently, this study was undertaken to evaluate the quality of water in the affected area.

Objectives of the Study

The objectives of the research are as follow:-

1. To identify the main sources of drinking water and household treatment practices in Biu, Konduga, and Maiduguri, and establish their implications for water quality and public health.
2. To examine the extent to which anthropogenic activities especially waste dumping, open defecation, and waste types contribute to surface water contamination in the study areas.
3. To establish statistical associations between LGAs and key factors such as water source, waste management, awareness levels, and reported waterborne diseases.

Literature Review

Eutrophication is an ecological reaction that occurs when an aquatic ecosystem receives excess nutrients, particularly nitrates and phosphates, from natural or artificial sources such as fertilizers or sewage. A common indicator of this process is the rapid multiplication or "bloom" of phytoplankton in response to nutrient enrichment. The phenomenon may result from human activities, including untreated sewage discharge and agricultural runoff, or occur naturally in areas where nutrients accumulate, such as depositional zones, or enter water bodies intermittently (Anthony, 2021).

Excessive nutrient input encourages abnormal plant growth and decay, favoring algae and plankton over more complex aquatic plants, which in turn leads to a decline in water quality. Phosphorus, which is a key nutrient required for plant growth, often acts as the limiting factor in freshwater ecosystems. Increased phosphorus availability accelerates algal growth, although not all phosphate compounds directly support algal development.

When algae die, they settle at the bottom, where bacteria decompose the organic matter, converting nutrients into inorganic forms. This decomposition process consumes large amounts of dissolved oxygen, depleting oxygen levels in deeper waters. Such hypoxic conditions threaten fish and other aquatic organisms, frequently resulting in their death. Additionally, when excess nutrients settle at the bottom of rivers, they reduce light penetration, thereby limiting photosynthesis for deep-water (abyssal) plants and animals. The rapid growth of aquatic plants, phytoplankton, and algal blooms alters the natural functioning of aquatic ecosystems, causing oxygen depletion essential for the survival of fish and shellfish (Lucas, 2017). Eutrophicated waters often appear turbid and may exhibit green, yellow, brown, or reddish coloration. Moreover, eutrophication diminishes the recreational, aesthetic, fishing, and hunting value of rivers, lakes, and estuaries.

It can also interfere with drinking water treatment, leading to potential health hazards. Although eutrophication may occur naturally, seasonal variations can accelerate it. For example, at the onset of the rainy season, runoff may transport decayed vegetation, livestock manure, and other organic materials into aquatic systems. Human activities further intensify this process. Abba (2016) noted that agricultural runoff, effluents from septic tanks and sewage systems, and other anthropogenic activities increase the flow of organic matter and inorganic nutrients into water bodies. Atmospheric nitrogen compounds can also enhance nitrogen levels in aquatic systems, while phosphorus is often identified as the key factor driving eutrophication, especially in lakes receiving “point source” pollution from sewage discharge.

Sources of surface water pollution

Water pollution is the introduction of contaminants into water bodies such as rivers, lakes, oceans, and groundwater. This contamination negatively impacts aquatic organisms, often causing significant harm to individual species, entire populations, and natural biological communities. Albert (2020) notes that water pollution occurs when pollutants are released into aquatic systems, either directly or indirectly, without sufficient treatment to remove toxic substances. It is regarded as one of the most serious global environmental challenges and is considered a leading cause of illness and mortality worldwide, with an estimated 14,000 deaths occurring daily as a result (WHO, 2018).

Water is deemed polluted when anthropogenic contaminants impair its quality to the extent that it becomes unsuitable for human consumption or when its capacity to sustain aquatic life, such as fish and other biotic communities, is significantly altered. Additionally, natural events like volcanic eruptions, algal blooms, storms, and earthquakes can also drastically affect water quality and disrupt ecological balance.

Waste water

Wastewater refers to the portion of water that has been utilized by households or industries and subsequently becomes mixed with various suspended or dissolved solids as shown in Table 1. Although it consists primarily of water—approximately 99%—only about 0.1% of it is composed of solid matter. The primary objective of wastewater treatment is to eliminate as much of this small fraction of contaminants as possible.

Effect of domestic wastes on surface water quality.

Environmental concerns have been on the rise due to the increasing generation of solid waste, garbage, and sewage, especially in urban areas. Human activities, in attempting to dispose of these wastes, have contributed significantly to environmental pollution. In traditional, underdeveloped societies—similar to the areas considered in this study—household waste was largely biodegradable and uniform. However, with modernization, household waste now comprises both biodegradable and non-biodegradable components. Previously, humans believed that the environment could absorb unlimited waste without harmful effects, but it has become evident that excessive pollution negatively impacts human health and overall well-being. Naturally occurring substances can become toxic when introduced into the environment in excessive quantities through anthropogenic activities.

The World Health Organization (WHO) reports that over 20% of the global population, approximately 1.3 billion people, lack access to safe drinking water, while more than 40% live without proper sanitation (Oastridge and Trent, 2018). Poor water quality continues to pose significant challenges worldwide, limiting the usability of this critical resource and, in severe cases, threatening human and animal life (Forum and Entwicklung, 2016). Water can be polluted by dissolved chemicals, suspended solid particles, or insoluble liquid droplets (Phernt *et al.,* 2016). Interestingly, even seemingly simple materials, such as paper, are highly engineered; modern paper is not merely compressed fibers but often contains coatings, binders, and advanced technological modifications (Borman, 2020).

Pollution impacts of agriculture on fresh waters

To properly assess the broad impacts of agriculture and explore possible mitigation measures, it is essential to define both agriculture and its associated impacts. Agriculture, in this context, refers to the alteration of natural landscapes to produce goods for subsistence or commercial use, whether for consumption or other purposes by settled human populations. This definition includes forestry, crop cultivation, biomass production for energy, and animal husbandry. The scale and intensity of agricultural practices vary significantly across regions and production systems.

The effects of agriculture on freshwater and marine environments are largely a consequence of landscape modifications. These effects include alterations in water chemistry, particularly nutrient depletion or enrichment (Hay Garth, 2017; Carpenter et al., 2018; Agouridis *et al.,* 2020; James *et al.,* 2015; Mechaffy *et al.,* 2018; Olson *et al.,* 2017), which often result in eutrophication and subsequent disruptions of aquatic food webs (Moss, 2020; Pretty et al., 2016; Moss et al., 2020).

Materials and Methods

Study Area

The study was conducted in Biu, Konduga, and Maiduguri Metropolitan Council (MMC)**,** all located in Borno State, Nigeria. Biu lies in the southern part of Borno and represents a semi-urban area with mixed agricultural and residential communities. It is characterized by seasonal streams, hand-dug wells, and boreholes as water sources. Konduga is predominantly rural and located close to Maiduguri. The area suffers from limited infrastructural development, and most households depend on surface water and traditional sanitation practices. Maiduguri**,** the state capital and largest urban center, has relatively better water and waste infrastructure but still faces challenges due to high population density, informal settlements, and internally displaced persons (IDP) camps.

These three LGAs were purposively selected to reflect the urban–semi-urban–rural contrast**,** which provides comparative insight into how domestic waste disposal and anthropogenic activities influence surface water quality across different settings.

Sample Size and Sampling Technique

A total of 150 respondents were selected for the study, with 50 respondents drawn from each LGA (Biu, Konduga, and Maiduguri)**.** This sample size was determined to ensure adequate representation and facilitate statistical comparison between the LGAs.

The study employed a multi-stage sampling technique**:**

1. ***Stage One – LGA Selection:*** The three LGAs (Biu, Konduga, and Maiduguri) were purposively selected to capture urban-rural variations.
2. ***Stage Two – Ward/Community Selection:*** Within each LGA, two wards were randomly selected to ensure coverage of diverse settlement types.
3. ***Stage Three – Household Selection:*** Within each ward, systematic random sampling was employed, with every third household visited until the required sample was obtained. In each household, one adult respondent was interviewed.

This procedure enhanced the representativeness of the sample while maintaining feasibility within the study timeframe.

Data Collection and Analysis

Data were collected through a household survey administered by trained enumerators who were fluent in English and Hausa. The survey lasted between 20–30 minutes per household. Respondents were assured of confidentiality and informed consent was obtained before participation. The FGDs involved 8–10 participants per group, stratified by gender, to capture diverse perspectives. Discussions were moderated using a semi-structured guide and were audio-recorded with permission from participants. Field notes were also taken to document non-verbal cues and community contexts.

Collected data were coded and entered into SPSS (Statistical Package for the Social Sciences) for analysis. The analysis involved:

- ***Descriptive Statistics*****:** Frequencies and percentages were computed to summarize distributions of responses across LGAs.
- ***Cross-tabulation:*** Data were cross-tabulated by LGA to compare patterns of water sources, waste practices, illnesses, and awareness.
- ***Chi-Square Tests of Association:*** Inferential statistics were applied to test the significance of associations between LGAs and key categorical variables (e.g., water source, treatment practices, and awareness levels). A significance threshold of $p < 0.05$ was adopted.
- ***Graphical Presentation*****:** Results were presented in the form of high-resolution charts (grouped bar, stacked bar, and pie charts) to enhance visualization and interpretation.

Qualitative data from FGDs were transcribed, coded, and thematically analyzed to highlight recurring themes and to triangulate with quantitative findings.

Result and Discussion

Primary sources of drinking water

The cross-tabulation in Table 2 shows marked LGA differences. Maiduguri **(**urban) shows the highest reliance on boreholes 50% of Maiduguri respondents, with notable use of vendor/sachet water**.** Konduga exhibits greater reliance on surface water rivers/streams 30% Maiduguri, while Biu falls between these extremes with a mixed pattern 20% river/stream.

The urban advantage of Maiduguri in water infrastructure is evident in the simulated distribution; rural/peripheral LGAs (Konduga, some parts of Biu) still depend heavily on surface water. Reliance on untreated surface water is a recognized driver of waterborne disease risk and is consistent with recent national WASH findings that many communities in Nigeria still depend on unimproved or inadequately managed sources. For national context, the Federal Ministry/UNICEF WASHNORM mapping highlights persistent gaps and spatial inequality in safe drinking water and sanitation coverage in Nigeria. (UNICEF, 2021)

Policy implication: targeting borehole construction and protecting surface intakes in Konduga and rural Biu would likely reduce reliance on rivers and hence exposure to microbial contamination.

Open defecation near water sources

The simulated data indicate open defecation occurs more commonly in Konduga and Biu (rural/peri-urban settings) than in Maiduguri, although “Occasionally observed” and “Rare” categories exist across all LGAs as shown in Figure 1. Nationally, open defecation remains a major concern in Nigeria and is a well-established source of faecal contamination in surface water, causing outbreaks and endemic diarrhoeal disease. The WASHNORM report and multiple academic studies note that millions practice open defecation in Nigeria, creating strong seasonal and spatial transmission risk. (UNICEF, 2021)

Interpretation: the link between open defecation and surface-water contamination is direct (faecal matter leaches/runoff into rivers and streams, especially during rains), increasing both acute outbreak risk (e.g., cholera) and endemic diarrheal disease burdens. Community-led total sanitation (CLTS) approaches and provision of latrines, plus behaviour change, are essential.

Frequency and nature of waterborne disease

Responses indicate that communities in Konduga and Biu report waterborne diseases “Very often” or “Often” more than Maiduguri consistent with greater reliance on unprotected sources. Across the three LGAs, the most common illness reported is diarrhea (simulated majority), followed by typhoid and skin infections; cholera is less common but noted in some responses. This aligns with epidemiological patterns: diarrheal illnesses are the most frequent outcome of poor water and sanitation. Notably, Borno State has previously reported cholera and acute watery diarrhea outbreaks associated with floods and displacement, underscoring the potential severity of contamination events (Reuters, 2024).
Interpretation: high self-reported frequency or awareness of waterborne illness indicates both real disease burden and community perception of water risks a window of opportunity for WASH interventions and surveillance.

Water treatment practices before drinking

Behavior shows boiling is the dominant treatment in Maiduguri (urban households more likely to boil), with filtering and no treatment more common in Konduga and Biu respectively. A substantial fraction across LGAs report no treatment, which elevates exposure risk.
Interpretation: the dominance of boiling in urban settings may reflect both awareness and ability to do so; the rural pattern of limited treatment suggests either lack of awareness, fuel constraints, or behavioral factors. Evidence from Nigerian studies finds that sachet water sometimes meets physico-chemical standards but storage/packaging/handling can lead to contamination — so treating water at household level remains a critical layer of protection in many contexts. Taylor, 2022).

Policy implication: promotion of low-cost household water treatment (safe storage, chlorination, simple filtration) plus safer source access can reduce disease burden.

Awareness of the dangers of drinking untreated water

Awareness levels vary by LGA (higher in Maiduguri, moderate in Konduga and Biu). Even where awareness exists, structural barriers (lack of alternative sources, lack of sanitation) may prevent behaviour change. National assessments show that awareness campaigns can work but must be accompanied by hardware provision (latrines, boreholes) and enforcement/collection services to be effective at scale. (UNICEF, 2021)

Interpretation: awareness alone is necessary but insufficient; integrated WASH interventions that combine information with accessible options (boreholes, latrines, waste collection) are required.

Summary

This study evaluates the impact of anthropogenic activities and domestic waste on surface water quality in Borno State, focusing on Biu, Konduga, and Maiduguri LGAs. Surface water, being highly exposed to environmental and human contamination, is vulnerable to pollutants such as sewage, domestic wastewater, agricultural runoff, and solid waste. The study emphasizes that poor waste disposal, open defecation, and uncontrolled human practices significantly increase microbial contamination, leading to widespread waterborne diseases like diarrhea, typhoid, cholera, and skin infections.

A cross-sectional survey involving 150 respondents (50 per LGA) revealed variations in primary water sources: Maiduguri showed higher reliance on boreholes and sachet water, while Konduga and Biu depended more on rivers and streams. Household water treatment practices were inconsistent, with urban residents more likely to boil water, while rural communities often consumed untreated water. Findings also highlight low awareness levels in rural areas and frequent reports of waterborne diseases, especially in Konduga and Biu. Laboratory evidence and literature confirm that surface waters contain pathogenic microorganisms including *E. coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Bacillus* species, which are associated with significant health risks.

Conclusion and Recommendations

The study concludes that surface water contamination in Borno State is largely driven by human activities such as indiscriminate waste disposal, sewage discharge, and open defecation. These practices contribute to high microbial loads and nutrient enrichment (eutrophication), which deteriorate water quality and promote disease transmission. Rural and peri-urban LGAs are more vulnerable due to poor sanitation infrastructure and reliance on unprotected water sources, while Maiduguri demonstrates relatively better access but still faces risks from population pressure and informal settlements.

The findings confirm a strong link between anthropogenic waste practices and public health, with waterborne diseases remaining prevalent in the study areas. Without proper intervention, the contamination of rivers and streams will continue to endanger human, livestock, and aquatic health.

- Construct and rehabilitate boreholes, protected wells, and piped water systems, especially in rural LGAs (Konduga and Biu) to reduce dependence on rivers and streams.
- Establish waste collection and treatment systems to minimize dumping near water sources.
- Promote low-cost household water treatment methods (boiling, chlorination, and filtration).
- Establish regular monitoring of surface water quality using microbiological and chemical tests.
- Encourage academic–government collaboration to design localized solutions addressing Borno’s specific water and sanitation challenges.

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Figures

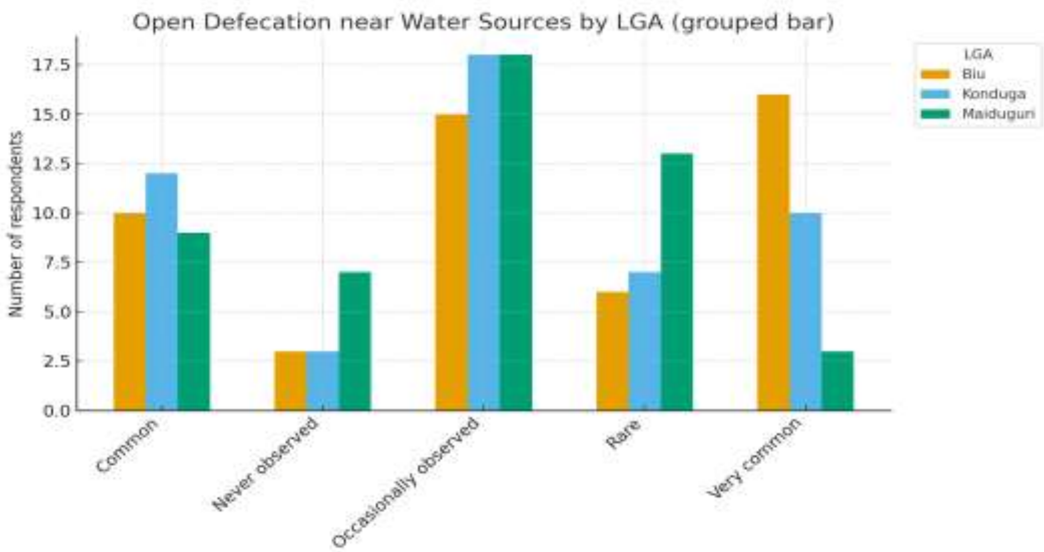

Figure 1: Open defecation near water sources by LGA

Tables

Table 1: This table below shows the types of waste water from house hold**.**

Type of waste water	**Sources of waste water**
1. Gray water	Washing water from the kitchen, bathroom, laundry (without faeces and urine)
2. Black water	Water from flush toilet (faeces, urine and flush water).
3. Yellow water	Urine from separated toilets and urinals.
4. Brown water	Black water without urine or yellow water.

Source: NIDAT (2015)

Table 2: Primary Source of Drinking Water by LGA (N=150)

Water Source	**Biu (n=50)**	**Konduga (n=50)**	**Maiduguri (n=50)**	**Total (N=150)**
Borehole	25 (50%)	20 (40%)	30 (60%)	75 (50%)
River/Stream	10 (20%)	15 (30%)	5 (10%)	30 (20%)
Rainwater	5 (10%)	5 (10%)	5 (10%)	15 (10%)
Vendor/Sachet	5 (10%)	7 (14%)	8 (16%)	20 (13.3%)
Others	5 (10%)	3 (6%)	2 (4%)	10 (6.7%)
Total	50 (100%)	50 (100%)	50 (100%)	150 (100%)

Source: Field survey 2025