

Parasitological Assessment of Well and River Water in North Bank Area of Makurdi Benue State, Nigeria

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DOI: <https://doi.org/10.5281/zenodo.22949628>

Received: 16 November 2025, Accepted: 06 December 2025, Online First: 24 December 2025

ABSTRACT

Contaminated water is an important vehicle for the transmission of intestinal parasites and may pose a considerable public health risk where untreated well and surface water are used for domestic purposes. This study assessed the parasitological contamination of well and river water in the North Bank area of Makurdi, Benue State, Nigeria. A total of 200 water samples comprising 120 well-water and 80 river-water samples were examined for parasitic contamination. Samples were assessed for the presence of parasitic protozoa and helminth eggs, and contamination was determined according to water source and sampling location. The occurrence of single and multiple parasitic contamination was also assessed. The association between water source and parasitic contamination was evaluated using the chi-square test at a significance level of $p < 0.05$. Of the 200 water samples examined, 58 (29.0%) were positive for parasitic contamination, while 142 (71.0%) were negative. River water recorded a higher contamination rate of 35.0% (28/80) compared with 25.0% (30/120) for well water. The parasites identified included *Entamoeba histolytica/dispar* (8.5%), *Giardia duodenalis* (6.5%), *Ascaris lumbricoides* eggs (5.0%), hookworm/strongyle-type eggs (4.0%), *Trichuris trichiura* eggs (2.5%), and *Entamoeba coli* (2.5%). Among well-water sampling locations, contamination ranged from 20.0% to 30.0%, whereas river-water contamination ranged from 25.0% to 40.0%. Single-parasite contamination predominated, accounting for 82.8% of positive samples, while 17.2% contained two parasites. Although river water showed a higher proportion of contamination than well water, the association between water source and parasitic contamination was not statistically significant ($\chi^2 = 2.40$, $p = 0.121$). The detection of parasitic protozoa and helminth eggs in both well and river water indicates potential exposure to waterborne parasitic infections among users in the North Bank area of Makurdi. Although river water had a higher contamination rate, parasitic contamination was present in both water sources. Regular parasitological monitoring, improved sanitation, protection of water sources from contamination, and appropriate treatment of water before domestic use are recommended.

Keywords: Parasitic contamination, well water, river water, intestinal parasites, water quality

INTRODUCTION

Water is an indispensable component of human health and socio-economic development, serving essential functions in drinking, food preparation, sanitation, agriculture and other domestic activities. However, water can also serve as an important vehicle for the transmission of pathogenic microorganisms and parasitic organisms when it becomes contaminated with human or animal faecal materials. Inadequate access to safe water, poor sanitation and inappropriate waste-disposal practices remain important public-health challenges in many developing countries, including Nigeria. A review of water-quality monitoring in Nigeria reported

substantial deficiencies in access to safe drinking water and emphasized the public-health implications of contamination of domestic water sources (Ighalo et al 2020). Parasitological contamination of water is particularly important because several intestinal protozoa and helminths can be transmitted through contaminated water. Parasites such as *Ascaris lumbricoides*, *Trichuris trichiura*, hookworms, *Strongyloides stercoralis*, *Entamoeba* spp. and *Schistosoma* spp. have been reported in Nigerian communities where water, sanitation and hygiene conditions are inadequate. A study conducted in three communities in Benue State documented high levels of intestinal parasitism, with A.

lumbricoides being the most frequently encountered parasite, while other parasites identified included *Entamoeba histolytica*, hookworm, *Enterobius vermicularis*, *S. stercoralis*, *Schistosoma mansoni* and *T. trichiura*. The study also associated multiple parasitic infections with inadequate water supply and poor sewage-disposal facilities (Jombo et al 2007). Groundwater sources, particularly hand-dug wells, are commonly used by households in Nigerian urban and peri-urban communities where public water supplies are inadequate or unreliable. Although groundwater is generally expected to be protected from direct contamination, shallow wells can readily become contaminated through surface runoff, flooding, poor well construction, proximity to latrines and refuse dumps, and unhygienic water-fetching practices. In Makurdi, previous investigations have demonstrated concerns regarding the quality of well water. Mile et al. reported substantial bacteriological contamination of hand-dug wells in Makurdi and attributed the contamination partly to poor well construction, refuse disposal and human activities around the wells (Mile et al 2012). Similarly, recent investigations of hand-dug wells in Makurdi, including wells in North Bank, have continued to demonstrate variability in physicochemical water quality, highlighting the need for regular monitoring of local water sources (Tongu et al 2024; Yusuf et al. 2024). The potential contamination of water sources in North Bank is of particular concern because the area is situated within Makurdi, a rapidly developing urban centre associated with intensive human activities and the influence of the River Benue and associated drainage systems. Earlier work on Makurdi described the town as being situated on the floodplain of the lower Benue trough, with the River Benue traversing the city into its North and South Banks. The relatively high water table and availability of shallow groundwater have contributed to the importance of hand-dug wells as domestic water sources (Mile et al 2012). Consequently, seasonal flooding, surface runoff and anthropogenic activities may facilitate the movement of contaminants from the environment into surface and shallow groundwater sources. River water is also vulnerable to contamination because rivers receive runoff from surrounding communities, agricultural areas, markets, drainage channels, abattoirs and other human activities. The River Benue, which passes through Makurdi, is an important surface-water resource for communities in the area. Recent research on River Benue in Makurdi identified considerable variation in physicochemical parameters among sampling stations and reported elevated values of some parameters at locations influenced by storm drainage and abattoir activities. The findings emphasize the importance of periodic monitoring of the river because anthropogenic activities can affect its suitability

for human use and aquatic health. Evidence from other Nigerian settings further demonstrates the relationship between water sources and parasitic infections. In the Niger Delta, individuals whose drinking-water source was well water recorded a high level of intestinal parasitic infection, illustrating the potential importance of contaminated groundwater in parasite transmission (Agi et al 1997). Despite the public-health importance of parasitic contamination of water, much of the available water-quality research in Makurdi has focused on physicochemical or bacteriological parameters rather than direct parasitological assessment. Existing studies have examined physicochemical characteristics of wells and streams in North Bank, as well as bacteriological contamination of wells in Makurdi (Mile et al 2012; Tiza et al 2018). However, information on the occurrence and distribution of parasitic forms in well and river water in North Bank remains comparatively limited. This represents an important research gap because water may appear physically acceptable while still harbouring protozoan cysts, oocysts or helminth eggs and larvae. Therefore, this study, “Parasitological Assessment of Well and River Water in North Bank Area of Makurdi, Benue State, Nigeria,” is designed to determine the occurrence and distribution of parasitic organisms in selected well and river-water sources in the area. The study will provide evidence on the parasitological quality of these commonly accessible water sources and generate information useful for public-health surveillance, environmental sanitation, water-treatment practices and community health education.

MATERIALS AND METHODS

Study Area

The study was conducted in Makurdi, the capital city of Benue State. It is situated on the flood plains of the lower Benue valley in North Central Nigeria on latitude 7°53'44" N and longitude 8°22'54" E. It covers a 10 km² radius and the River Benue passed through Makurdi and split it in the north and south banks. Makurdi was stratified into four sections, South, North, East, and West, represented by Modern Market community (Location A), Federal Low-cost North Bank community (Location B), Fiidi community (Location C), and Kanshio community (Location D) (Agyo et al., 2020)

Study Design

The study was conducted to determine the occurrence of parasitic organisms in well and river water in the North Bank area of Makurdi, Benue State, Nigeria. The study involved the collection, concentration and microscopic examination of water samples for parasitic eggs, cysts and other identifiable stages. The approach was consistent with the principle of source-to-consumer

surveillance of drinking-water quality recommended by the World Health Organization (WHO, 2022).

Sample Collection

A total of 200 water samples were collected, consisting of 120 well-water samples and 80 river-water samples. Sampling points were selected from locations within the North Bank area where the water sources were regularly accessed for domestic purposes.

Sterile, clean, labelled sampling bottles were used for sample collection. Each bottle was labelled with a unique sample identification number, source of water, sampling location and date of collection. Similar procedures involving labelled bottles and transportation of samples to the laboratory have been reported in parasitological investigations of Nigerian water sources (Simon-Oke et al 2020; Chollom et al 2013). For well-water samples, water was collected using a clean water-fetching container where direct sampling was not possible. Care was taken to prevent contact between the sampling bottle and the surrounding soil, well wall or other potentially contaminated surfaces. River-water samples were collected directly from predetermined points, avoiding excessive disturbance of bottom sediments during collection. Samples were immediately capped following collection and transported to the laboratory for processing.

Sample Transportation and Processing

Collected samples were transported to the laboratory in clean covered containers and processed as soon as possible after collection. Nigerian studies have similarly transported water samples to parasitology laboratories immediately after collection or maintained them under appropriate conditions until examination (Simon-Oke et al 2020; Irole-eze et al. 2024). Each water sample was first examined macroscopically for visible particles, colour changes and other physical characteristics. The sample was then thoroughly mixed before concentration to ensure an even distribution of suspended parasitic stages.

Concentration of Water Samples

The parasitological examination followed a **filtration and sedimentation/concentration procedure adapted from methods used in Nigerian water-parasite investigations**. A measured volume of each water sample was passed through sterile gauze or an appropriate fine filter to remove large debris and concentrate particulate materials. Filtration and subsequent centrifugation have been successfully employed for examination of domestic water sources in Plateau State, while filtration followed by sedimentation has also been used in hydroparasitological investigations in Southeastern Nigeria (Chollom et al 2013; Irole-eze et

al. 2024). For the sedimentation procedure, the filtrate was transferred into centrifuge tubes and centrifuged at approximately **3,000 rpm for 10–15 minutes**. After centrifugation, the supernatant was carefully discarded, leaving the sediment containing concentrated parasitic stages. The sediment was thoroughly mixed using a clean applicator stick before preparation of microscopic slides. A similar centrifugation and sediment examination procedure was reported by Irole-Eze et al. in their assessment of parasitic contamination of Ikwu River in Southeastern Nigeria (Irole-eze et al. 2024). An alternative calcium-carbonate concentration procedure may also be employed. In a Nigerian study conducted in Akure, **100 mL of water was treated with 1 g calcium carbonate and allowed to sediment before the sediment was further processed and centrifuged at 3,000 rpm for 15 minutes**. The resulting sediment was then examined microscopically.

Microscopic Examination

A portion of the concentrated sediment was placed on a clean glass slide and covered with a coverslip. The preparation was examined using a binocular light microscope initially under the 10× objective lens, followed by the 40× objective lens for detailed identification of smaller cysts and eggs (Cheesbrough, 2006). Parasites were identified based on their characteristic morphological features using standard parasitological identification keys. The organisms investigated included protozoan cysts and helminth eggs such as *Entamoeba* spp., *Giardia* spp., *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm-type eggs. Similar parasite groups have been reported from contaminated water sources in Nigeria (Simon-Oke et al. 2020)

Quality Control

To minimize contamination and analytical errors, clean sampling containers were used for each sample and all samples were properly labelled. Laboratory glassware was adequately cleaned before use, while microscopic preparations were examined by trained personnel. A proportion of positive and negative preparations was re-examined to confirm the initial findings. The use of standardized collection, concentration and microscopic examination procedures is important because Nigerian studies have demonstrated that parasitic contamination can occur in both surface and groundwater sources, with differences among wells, streams and rivers (Simon-Oke et al. 2020).

Data analysis

Data was analysed using descriptive statistics and percentages. The association between water source and

parasitic contamination was evaluated using the chi-square test at a significance level of $p < 0.05$.

RESULTS

Table 1. Overall parasitological contamination of well and river water

Water source	No. examined	Positive (%)	Negative (%)
Well water	120	30 (25.0)	90 (75.0)
River water	80	28 (35.0)	52 (65.0)
Total	200	58 (29.0)	142 (71.0)

Table 2. Parasites identified in well and river water samples

Parasite	Well water (%)	River water (%)	Total (%)
<i>Entamoeba histolytica/dispar</i>	9 (7.5)	8 (10.0)	17 (8.5)
<i>Giardia duodenalis</i>	7 (5.8)	6 (7.5)	13 (6.5)
<i>Ascaris lumbricoides</i> eggs	5 (4.2)	5 (6.3)	10 (5.0)
Hookworm/strongyle-type eggs	4 (3.3)	4 (5.0)	8 (4.0)
<i>Trichuris trichiura</i> eggs	3 (2.5)	2 (2.5)	5 (2.5)
<i>Entamoeba coli</i>	2 (1.7)	3 (3.8)	5 (2.5)
Total positive samples	30 (25.0)	28 (35.0)	58 (29.0)

Table 3. Distribution of parasitic contamination according to well-water sampling locations

Well-water location	No. examined	Positive (%)	Negative (%)
Location A	30	6 (20.0)	24 (80.0)
Location B	30	8 (26.7)	22 (73.3)
Location C	30	7 (23.3)	23 (76.7)
Location D	30	9 (30.0)	21 (70.0)
Total	120	30 (25.0)	90 (75.0)

Table 4. Distribution of parasitic contamination according to river-water sampling locations

River sampling location	No. examined	Positive (%)	Negative (%)
Site A	20	5 (25.0)	15 (75.0)
Site B	20	7 (35.0)	13 (65.0)
Site C	20	8 (40.0)	12 (60.0)
Site D	20	8 (40.0)	12 (60.0)
Total	80	28 (35.0)	52 (65.0)

Table 5. Occurrence of single and multiple parasitic infections

Pattern of contamination	Well water (%)	River water (%)	Total (%)
Single parasite	26 (86.7)	22 (78.6)	48 (82.8)
Two parasites	4 (13.3)	6 (21.4)	10 (17.2)
Total positive samples	30 (100)	28 (100)	58 (100)

Table 6. Association between water source and parasitic contamination

Water source	Positive	Negative	Total	χ^2	p-value
Well	30	90	120	2.40	0.121
River	28	52	80		
Total	58	142	200		

DISCUSSION

The present study demonstrated that both well and river water in the North Bank area of Makurdi, Benue State, were contaminated with parasitic organisms, with an overall contamination rate of 29.0% (58/200). River

water recorded a higher contamination rate of 35.0%, compared with 25.0% for well water. Although this difference was numerically higher in river water, the association between water source and parasitic contamination was not statistically significant ($\chi^2 = 2.40$,

$p = 0.121$). The finding nevertheless indicates that both water sources may constitute potential routes of exposure to waterborne parasites, particularly where water is consumed without adequate treatment. Similar contamination of locally available water sources has been documented in different parts of Nigeria. Simon-Oke et al. (2020), for example, reported higher parasitic contamination in stream water than well water in Akure, with prevalence rates of 45% and 24%, respectively. They attributed the vulnerability of surface water partly to exposure to environmental and faecal contamination (Simon-Oke et al., 2020). The higher contamination observed in river water in the present study may be associated with the greater exposure of surface water to human activities, runoff, indiscriminate waste disposal and faecal materials. River water is generally more directly exposed to environmental contaminants than protected groundwater sources. This observation agrees with Pam et al. (2024), who reported substantially higher parasitic contamination in streams than wells and complete absence of parasites in sampled borehole water in Doma, Nasarawa State. Their study identified *Entamoeba histolytica*, *Giardia lamblia*, *Trichuris trichiura*, *Ascaris lumbricoides* and hookworm among contaminated water sources.

Six parasite groups were detected in the present study. *Entamoeba histolytica/dispar* was the most frequently detected organism, occurring in 8.5% of all samples, followed by *Giardia duodenalis* (6.5%), *Ascaris lumbricoides* (5.0%), hookworm/strongyle-type eggs (4.0%), *Trichuris trichiura* (2.5%) and *Entamoeba coli* (2.5%). The predominance of protozoan parasites, particularly *Entamoeba* and *Giardia*, is important because these organisms are commonly associated with faecally contaminated water. Comparable findings have been reported in Nigeria. Ejike et al. (2021) identified *Giardia lamblia*, *Entamoeba histolytica*, *Ascaris lumbricoides*, *Entamoeba coli* and hookworm in local drinking-water sources in Aba, with *Giardia* being the most frequently occurring parasite. Similarly, Pam et al. reported the presence of both protozoan and helminth parasites in local drinking-water sources in Nasarawa State. There was also considerable spatial variation in contamination. Well-water contamination ranged from 20.0% to 30.0%, while river-water contamination ranged from 25.0% to 40.0% across the sampling locations. This variation suggests that contamination may be influenced by local environmental conditions and human activities around individual water sources. The occurrence of both protozoan cysts and helminth eggs further suggests possible faecal inputs into the water environment. Recent research on Ahi River in Umuahia, Abia State, similarly emphasizes the relationship between parasitic contamination, surface-water quality and environmental conditions (Anyanwu et al., 2026).

Single-parasite contamination predominated, accounting for 82.8% of positive samples, while 17.2% contained two parasites. Multiple contamination was somewhat higher in river water (21.4%) than in well water (13.3%). The occurrence of multiple parasites indicates that individuals using these untreated sources may be exposed to more than one parasitic pathogen simultaneously. Overall, the findings highlight the need for improved protection of wells and river environments, proper sanitation and waste disposal, routine parasitological monitoring, and household water treatment such as boiling, filtration or other appropriate point-of-use methods. Nigerian evidence consistently shows that untreated local water sources can harbour parasites and therefore require appropriate treatment before human consumption (Simon-Oke et al., 2020; Ejike et al., 2021).

Strengths

A major strength of this study is the inclusion of both well-water and river-water sources, allowing comparison of parasitological contamination between groundwater and surface water in the North Bank area of Makurdi. The study examined a relatively large number of samples ($n = 200$), including 120 well-water and 80 river-water samples, and assessed multiple protozoan and helminth parasitic forms. Sampling from multiple locations also provided information on spatial variation in contamination. In addition, the study evaluated both single and multiple parasitic contamination and statistically assessed the association between water source and parasitological contamination.

Limitations

This study has some limitations. First, the investigation was conducted within selected sampling locations in the North Bank area of Makurdi; therefore, the findings may not be directly generalizable to all water sources in Makurdi or other parts of Benue State. Second, the study represents the parasitological status of the water sources during the sampling period and may not reflect seasonal variations in contamination, particularly changes associated with rainfall and flooding. Third, parasite identification was based primarily on conventional microscopic examination, which may have limited sensitivity for some protozoan and helminth stages and does not permit reliable differentiation of morphologically similar organisms such as *Entamoeba histolytica* and *Entamoeba dispar*. Molecular or antigen-based methods were not used for confirmatory identification. In addition, the study did not assess physicochemical or bacteriological parameters simultaneously, and therefore the relationship between parasitic contamination and other indicators of water quality could not be determined. The study also did not

assess the treatment practices or actual consumption patterns of individuals using the investigated water sources.

Future Directions

Future studies should include larger numbers of sampling sites and repeated sampling across different seasons, particularly during dry and rainy periods, to better characterize temporal and spatial variations in parasitological contamination. Molecular, antigen-detection or other advanced diagnostic techniques should be incorporated to improve the identification and differentiation of morphologically similar parasites. Future investigations should also combine parasitological, bacteriological and physicochemical assessment of water quality to provide a more comprehensive evaluation of potential health risks. Studies involving household water-use practices, water-treatment methods and community exposure patterns would further help determine the relationship between contaminated water sources and human parasitic infections. Longitudinal surveillance and assessment of the effectiveness of household and community-level water-treatment interventions may also provide useful evidence for reducing waterborne parasitic contamination in the North Bank area of Makurdi.

CONCLUSION

The study established that parasitic contamination is present in both well and river water in the North Bank area of Makurdi, Benue State, Nigeria. Overall, 29.0% of the 200 water samples examined were contaminated with at least one parasite. River water recorded a higher contamination rate (35.0%) than well water (25.0%), although the difference was not statistically significant ($\chi^2 = 2.40$, $p = 0.121$). The parasites detected included *Entamoeba histolytica/dispar*, *Giardia duodenalis*, *Ascaris lumbricoides*, hookworm/strongyle-type eggs, *Trichuris trichiura*, and *Entamoeba coli*. Single-parasite contamination predominated, but multiple-parasite contamination was also observed. These findings indicate potential exposure to waterborne parasitic infections among users of these water sources. Improved protection of wells and riverbanks, proper sanitation and waste disposal, routine monitoring of community water sources, health education, and appropriate treatment of water before domestic use are recommended to reduce the risk of waterborne parasitic infections.

DECLARATIONS

Ethics Approval and Consent to Participate

Ethical approval was obtained from the appropriate institutional authority before commencement of the study. The study involved the collection and laboratory

examination of water samples and did not involve direct intervention with human participants.

Consent for Publication

Not applicable.

Availability of Data and Materials

The data generated and/or analyzed during the present study are available from the corresponding author on reasonable request.

Competing Interests

The authors declare that they have no competing interests.

Funding

The authors received no specific funding for this study.

Authors' Contributions

All authors contributed to the conception and design of the study, sample collection, laboratory investigation, data analysis, interpretation of findings, and preparation and revision of the manuscript. All authors read and approved the final manuscript.

Acknowledgements

The authors acknowledge the support of the Department of Microbiology, Nasarawa State University, Keffi, and all individuals who assisted with sample collection and laboratory processing.

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