International Journal of Community Medicine and Public Health
Omolo PO et al. Int J Community Med Public Health. 2026 Jun;13(6):2596-2601
https://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20261734

Original Research Article

Microbiological contamination of household water and its effects on public health in Likoni sub county, Kenya

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Received: 14 October 2025
Revised: 13 May 2026
Accepted: 19 May 2026

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ABSTRACT

Background: Access to safe drinking water is crucial for human health, yet many communities, face chronic shortages. Residents often rely on wells and boreholes that are prone to contamination due to poor hygiene, overcrowding, improper waste disposal, and environmental pollution. This has led to frequent outbreaks of waterborne diseases, notably diarrhea. This study assessed microbial contamination in water from boreholes and household storage containers and evaluated water handling practices in Likoni Sub-County.
Methods: A descriptive cross-sectional and case-control study was conducted among 54 households (29 case households and 25 controls). Water samples were collected at the point of source (POS) and point of use (POU) and analysed using the Most Probable Number (MPN) method. Data were analysed using SPSS version 20.0.
Results: Microbial contamination was detected in a substantial proportion of samples. Among case households, *Escherichia coli* was present in 58% of samples at POS and 60% at POU, compared to 33% and 5%, respectively, among control households. Overall, 35% of samples tested positive for *E. coli*. Mean total coliform counts were higher in case households than in controls.
Conclusions: Household water in Likoni Sub-County is contaminated with faecal indicator bacteria, posing a public health risk. Interventions focusing on water treatment, safe storage, hygiene education, and improved sanitation infrastructure are recommended.

Keywords: Water contamination, *Escherichia coli*, Total coliforms, Household water, WASH, Kenya

INTRODUCTION

Access to safe and sufficient water is a fundamental human need and a cornerstone of public health. Despite global progress, poor water quality remains a leading cause of disease outbreaks. The Joint Monitoring Programme (JMP) estimates that 1.8 billion people globally consume fecal-contaminated water, while 1.1 billion use water with moderate health risks due to Escherichia coli (E. coli) levels exceeding 10 CFU/100 ml.[1] Alarmingly, 10% of improved water sources still contain over 100 CFU/100 ml of contaminants.[2] A 2017 study found that 83.4% of water samples in Mombasa County were contaminated with coliform bacteria, and 60.3% tested positive for E. coli. E. coli levels have been found to range from 2 to 1600 CFU/100 ml due to sewage pollution and storm water runoff at Madubaha Beach.[3] Poor hygiene, waste disposal, and overcrowding further elevate disease risks. In Africa, the problem is more acute in rural and peri-urban areas with limited water and sanitation infrastructure. Kenya, for example, reports that waterborne diseases account for 10% of all deaths, with diarrhea being a major cause of morbidity, particularly among children under five.[4]

In Likoni Sub-County, Mombasa County, residents experience chronic water scarcity and depend on alternative sources like wells and boreholes, often situated near pit latrines and septic tanks. This proximity increases the risk of fecal contamination, especially during rainy seasons when runoff introduces additional pollutants. To address these challenges, a holistic approach is essential combining microbiological assessment of water sources, evaluation of water handling practices, and targeted interventions. This study aims to fill critical knowledge gaps and offer evidence-based recommendations to improve water safety and public health outcomes in Likoni Sub-County. The objective of the study was to determine the microbiological quality of water collected in 54 households (HHs) at the POS and POU where total coliforms, faecal coliforms were isolated.

METHODS

Research study design

This study adopted a descriptive Cross-Sectional and Case–Control study design and was conducted between January 2024 to December 2024 in Likoni Sub County, Mombasa, Kenya. The study assessed the microbiological quality of household water and associated handling practices in Likoni Sub County. The study was conducted in five purposively selected wards Mtongwe, Bofu, Timbwani, Likoni, and Shika Adabu based on their high burden of diarrhoeal diseases as reported in the District Health Information System (DHIS), frequent water shortages, and reliance on borehole water for domestic use.

Study population and sampling

The study population comprised households that rely on borehole water for drinking and domestic purposes. The study population comprised households that rely on borehole water for drinking and domestic purposes. Households were categorized into two groups: Case households: Households reporting at least one episode of water-related illness (e.g., diarrhoea) within the preceding two weeks. Control households: Households with no reported water-related illness during the same period.

Sample collection

Water samples were collected from two points: Point of Source (POS): Borehole water and Point of Use (POU): Household storage containers. Samples were collected aseptically using sterile 500 ml polyethylene bottles. At each sampling point, bottles were rinsed with the sample water (except when pre-sterilized bottles with sodium thiosulfate were used) and filled leaving approximately 2-3 cm headspace to allow mixing. Each sample was labeled with a unique identifier, date, location, and sampling point. Samples were immediately placed in a cooler box maintained at approximately 4°C and transported to the laboratory within 6 hours, with analysis conducted within 24 hours in accordance with standard guidelines.

Microbiological analysis

Microbial water quality was assessed using the Most Probable Number (MPN) technique following American Public Health Association (APHA, 2005) standard methods.

Detection of total coliforms

The multiple-tube fermentation technique was used: Presumptive test was first carried out where measured volumes of water (10 ml, 1 ml, and 0.1 ml) were inoculated into tubes containing lactose broth with inverted Durham tubes. Tubes were incubated at 35-37°C for 24-48 hours. Formation of acid (color change) and gas indicated presumptive coliform presence. Confirmed test was carried out on positive tubes where they were sub-cultured into Brilliant Green Lactose Bile (BGLB) broth and incubated at 37°C for 24-48 hours.

Gas production confirmed the presence of total coliforms. Further, detection of Faecal Coliforms and Escherichia coli was done on positive presumptive tubes were inoculated into E. coli broth and incubated at 44.5°C for 24 hours. Gas production indicated the presence of thermotolerant (faecal) coliforms. For confirmation of Escherichia coli, samples were streaked onto MacConkey agar and incubated at 37°C for 24 hours. Typical pink colonies on MacConkey were subjected to biochemical tests, including: Indole test, Methyl Red test, Voges-Proskauer test and Citrate utilization test (IMViC). Isolates showing Indole positive, Methyl Red positive, Voges-Proskauer negative, and Citrate negative (IMViC: ++--) were confirmed as E. coli.

Enumeration of bacteria

MPN values were determined using standard MPN tables based on the number of positive tubes in each dilution series. Results were expressed as MPN/100 ml.

Data collection on water handling practices

A structured questionnaire was administered to collect data on: Water sources and storage practices, Household water treatment methods, Hygiene practices related to water handling Sanitation conditions

Data management and statistical analysis

Data were entered into Microsoft Excel (2013) and exported to IBM SPSS version 20.0 for analysis. Descriptive statistics (frequencies, proportions, means, and standard deviations) were used to summarize data.

Ethical considerations

Ethical approval for the study was obtained from the Technical University of Mombasa Institutional Ethics Review Committee and granted (TUM SERC MSC/04/2023). Informed consent was obtained from all participating households prior to sample collection and interviews. Confidentiality of participant information was strictly maintained.

RESULTS

A total of 54 households were included in this study, comprising 29 case households and 25 control households.

The distribution of total coliforms across the study wards is presented in Table 1. Case households consistently showed higher contamination levels compared to control households in all wards. For instance, in Likoni ward, 7 case samples tested positive for total coliforms, whereas none of the control samples were contaminated.

Table 1: Distribution of total coliform-positive samples by ward and household type.

Ward	Case (+)	Case (−)	Control (+)	Control (−)
Bofu	5	0	1	4
Likoni	7	2	0	5
Mtongwe	6	0	1	4
Shika Adabu	4	0	0	6
Timbwani	5	0	0	4

Table 2: Distribution of *Escherichia coli*-positive samples by ward.

Ward	Case (+)	Case (−)	Control (+)	Control (−)
Bofu	2	3	1	4
Likoni	6	3	0	5
Mtongwe	4	2	1	4
Shika Adabu	3	1	0	6
Timbwani	3	2	0	4

Overall, mean total coliform counts were substantially higher in case households compared to controls, as summarized in Table 4. This difference is further illustrated in Figure 1, which shows higher mean microbial loads among case households, indicating a greater contamination burden.

Table 3: Proportion of water samples positive for *Escherichia coli* at POS and POU.

House-hold type	Sampling point	Total samples	Positive	(%)
Case	POS	24	14	58
Case	POU	5	3	60
Control	POS	3	1	33
Control	POU	22	1	5
Total	—	54	19	35

The distribution of *E. coli* contamination by ward is shown in Table 2. Higher prevalence was observed among case households across all wards. Likoni and Mtongwe wards recorded some of the highest numbers of *E. coli*-positive samples among case households.

Table 4: Mean total coliform counts (MPN/100 ml) by household type.

Group	N	Mean (MPN/100 ml)	SD
Case	29	1739.12	±611.15
Control	25	348.20	±778.60

The proportion of water samples contaminated with E. coli at the point of source (POS) and point of use (POU) is summarized in Table 3. Among case households, contamination was high at both POS (58%) and POU (60%), indicating that water was already contaminated at the source and remained contaminated at the household level. In contrast, control households showed a reduction in contamination from POS (33%)-POU (5%), suggesting better water handling and storage practices.

The mean total coliform counts in household water differed markedly between case and control households, as shown in Table 4. Case households recorded a substantially higher mean coliform count (1739.12 MPN/100 ml;SD±611.15) compared to control households (348.20 MPN/100 ml;SD±778.60), indicating a higher level of microbial contamination.

DISCUSSION

This study demonstrated substantial microbiological contamination of household water in Likoni Sub-County, with contamination evident at both the point of source (POS) and point of use (POU). The presence of *Escherichia coli* in 35% of all samples confirms widespread faecal contamination, posing a significant public health risk. These findings are consistent with global estimates indicating that a large proportion of populations in low-resource settings are exposed to faecally contaminated drinking water 1. The high prevalence of *E. coli* at the POS among case households

(58%) suggests that borehole water sources are already contaminated prior to household handling. This finding is consistent with studies conducted in Kenya and other low-resource settings, where groundwater contamination has been linked to the proximity of water sources to pit latrines, septic tanks, and poorly managed waste disposal systems.[2-4] Similar observations were reported in Isiolo County, Kenya, where borehole contamination was attributed to inadequate sanitation infrastructure and environmental exposure.[5] Furthermore, studies in Mombasa County have reported high levels of coliform contamination in groundwater and recreational water sources, often associated with sewage intrusion and surface runoff.[3] These findings support the current study's observation that environmental factors such as flooding and poor drainage contribute significantly to microbial contamination of water sour.[8]

Notably, contamination levels remained high at the POU among case households (60%), indicating that unsafe water storage and handling practices play a critical role in maintaining or exacerbating contamination. This aligns with previous research showing that water quality frequently deteriorates between collection and consumption due to factors such as unclean storage containers, lack of water treatment, and poor hygiene practices.[6] In contrast, the marked reduction in contamination from POS (33%)-POU (5%) among control households suggests that appropriate household-level interventions such as boiling, chlorination, or safe storage can effectively reduce microbial contamination.

The significantly higher mean total coliform counts observed in case households further reinforce the association between poor water quality and the occurrence of water-related illness. This is consistent with global evidence indicating that exposure to faecally contaminated water is a major risk factor for diarrhoeal diseases, particularly in densely populated and resource-limited settings.[7] The variation in contamination across different wards may reflect differences in population density, sanitation coverage, and environmental conditions. Densely populated areas with inadequate waste management are more likely to experience higher contamination levels, as observed in this study. These findings are in line with global recommendations emphasizing the importance of integrated water, sanitation, and hygiene (WASH) interventions in reducing disease burden.[7] Overall, the findings highlight the dual contribution of environmental contamination at the source and behavioral factors at the household level, underscoring the need for a multi-barrier approach to safe water provision.

Limitation

The study faced several limitations that could affect the interpretation and generalization of its findings. A limited sample size due to time, budget, and logistical constraints restricted the number of households and water samples analyzed. Sampling conducted at a single point in time may have also failed to capture seasonal variations in contamination, while access challenges in informal settlements could further limit coverage. Laboratory constraints, such as testing only selected microbial indicators may have reduced the accuracy and scope of microbiological results. Reliance on self-reported health data introduced recall bias, and some participants may have underreported illness. Establishing direct causation between contaminated water and health outcomes was also difficult because of confounding factors like sanitation and food hygiene practices. The cross-sectional design limited the ability to observe long-term trends. Household water handling practices varied widely and may have influenced contamination levels in ways that are hard to control. Additionally, the study's focused on Likoni sub-County and restricted the geographical generalizability of results. Incomplete or inconsistent health records and potential ethical or consent challenges may further have affected data completeness and reliability.

CONCLUSION

This study demonstrated significant microbiological contamination of household water in Likoni sub-county at both the point of source and point of use. The detection of *Escherichia coli* in a substantial proportion of samples indicates widespread faecal contamination, posing a considerable public health risk.

Higher contamination levels observed among case households, particularly the persistence of contamination from source to household storage, highlight the combined influence of unsafe water sources and poor handling practices. In contrast, the lower contamination levels at the point of use among control households suggest that appropriate household-level interventions, such as water treatment and safe storage, can effectively reduce microbial contamination.

Overall, the findings underscore the need for integrated interventions targeting both environmental factors and household behaviors to improve water quality and reduce the burden of waterborne diseases in the study area.

Recommendations

The study recommends that:

Strengthen community-based education programs on water hygiene

Establish regular community workshops to educate residents on water treatment methods, such as chlorination and boiling, and the importance of safe water storage practices. Partnering with local health workers, community leaders, and NGOs can extend the reach of these workshops, ensuring tailored approaches that address specific knowledge gaps within the community.

Integrate water hygiene education into schools and community centers to reach younger demographics and foster long-term behavior change, emphasizing the importance of clean water handling practices.

Enhance borehole infrastructure and sanitation facilities

Implement policies mandating minimum distances between boreholes and sanitation facilities, such as pit latrines, in compliance with WHO guidelines. Providing technical support for borehole construction to communities could improve water safety and reduce contamination risks from runoff and flooding.

Develop centralized sanitation facilities in densely populated areas where boreholes are frequently used. These facilities should include hand washing stations and accessible latrines, which can significantly reduce water contamination sources and foster hygiene practices.

Promote access to low-cost and consistent water treatment supplies

Offer subsidized chlorination supplies and simple filtration devices to households, especially low-income ones, through local health units or community distribution points. Additionally, partnerships with NGOs could help provide resources for sustained chlorination and boiling methods to reduce microbial contamination.

Encourage the use of solar water disinfection (SODIS) where applicable, which requires minimal resources and has proven effective in removing pathogens in other rural settings.

Establish routine water quality testing and feedback mechanisms

Set up a water quality monitoring program in partnership with Mombasa county's public health department, where regular microbial assessments are conducted for borehole water and household storage containers. Such a program could provide feedback to residents, enabling them to make informed decisions regarding water safety. Use local community centers to post regular updates on water quality findings, including accessible data visualizations (e.g., maps showing contamination hotspots) to keep residents informed of high-risk areas.

Develop and enforce local water and sanitation policies

Collaborate with county governments to establish regulations that mandate routine borehole testing and maintenance, safe disposal of wastewater, and clean water provision in high-risk areas. NGOs can assist in policy advocacy and support community-based interventions that align with these policies. Strengthen community ownership by involving local leaders in policy discussions and encouraging feedback from residents on sanitation challenges and needed resources, fostering a sense of accountability and involvement

ACKNOWLEDGEMENTS

The authors wish to express their sincere gratitude to the Technical University of Mombasa, particularly the Department of Environment and Health Sciences, for providing academic guidance and institutional support during this study. The authors also acknowledge the Kenya Coast National Polytechnic for granting access to laboratory facilities and supporting the microbiological analysis of water samples. Appreciation is further extended to the staff and collaborators who assisted in data collection and laboratory work and deeply grateful to the households in Likoni sub-county who participated in this study for their cooperation and willingness to provide samples and information.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee (TUM SERC MSC/04/2023)

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Cite this article as: Omolo PO, Ayieko SY, Gicharu GK, Gilumba PO, Kinya CM, Gande L. Microbiological contamination of household water and its effects on public health in Likoni sub county, Kenya. Int J Community Med Public Health 2026;13:2596-601.