INTERNATIONAL JOURNAL OF RESEARCH AND SCIENTIFIC INNOVATION (IJRSI)
ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VI June 2026

Assessment of Water Quality at Maasai Mara University and Surrounding Areas

Shevine Chebet[1], Doryce Ndubi[1] and Paul M. Wanjala[1,*]

[1]Department of Biological Sciences, School of Pure and Applied Sciences, Maasai Mara University, P.O. Box 861-20500, Narok, Kenya

DOI: https://doi.org/10.51244/IJRSI.2026.1306000126

Received: 04 June 2026; Accepted: 09 June 2026; Published: 26 June 2026

ABSTRACT

Access to safe drinking water remains a major public health concern, particularly in rapidly growing institutional and peri-urban environments. This study assessed the physicochemical and microbiological quality of water sources within Maasai Mara University and its surrounding areas in Narok County, Kenya. The objective was to determine water quality status, evaluate compliance with World Health Organization (WHO) and Kenya Bureau of Standards (KEBS) guidelines, and identify potential contamination risks. A cross-sectional analytical study design was employed. Water samples were collected from selected groundwater and surface water sources, including boreholes, taps, bottled water, and river water. Physicochemical parameters (temperature, pH, conductivity, and dissolved oxygen) were analyzed using standard laboratory procedures, while microbiological quality was assessed using MacConkey agar, Eosin Methylene Blue (EMB) agar, Gram staining, and IMViC biochemical tests. Data was analyzed using descriptive statistics and one-way analysis of variance (ANOVA) at a significance level of $p < 0.05$. Results indicated generally acceptable physicochemical water quality, with mean temperature (21.57 ± 0.18°C), conductivity (108.03 ± 1.40 μS/cm), and dissolved oxygen (9.61 ± 0.47 mg/L) falling within WHO permissible limits. However, pH values varied from slightly acidic to neutral (5.72–7.25), with some sources falling below recommended standards. Microbiological analysis revealed the presence of coliform bacteria in multiple sources, with Escherichia coli confirmed in river water, indicating fecal contamination. Bottled water also showed unexpected microbial contamination. ANOVA results showed significant variation in pH and temperature among sampling sites ($p < 0.05$), while conductivity and dissolved oxygen showed no significant differences. The study concludes that although physicochemical water quality is largely acceptable, microbiological contamination poses a significant public health risk, particularly in surface water and selected treated sources. These findings highlight the need for continuous water quality monitoring, improved sanitation practices, and strengthened regulatory enforcement to ensure safe drinking water within the study area.

Keywords: Water quality, microbiological contamination, physicochemical parameters, Escherichia coli.

INTRODUCTION

Background of Study

Water is an essential natural resource that supports human survival, ecosystem functioning, economic development, and public health. Access to safe drinking water has been recognized as a fundamental human right and is a key component of the Sustainable Development Goals (SDGs), particularly Goal 6, which aims to ensure availability and sustainable management of water and sanitation for all [1]. Despite significant progress in water supply and sanitation services globally, an estimated two billion people continue to consume water contaminated with fecal matter, exposing them to a variety of waterborne diseases [2].

Water quality refers to the physical, chemical, and microbiological characteristics of water that determine its suitability for specific uses. Safe drinking water should be free from pathogenic microorganisms, toxic chemicals, and objectionable physical characteristics such as excessive turbidity, color, taste, and odor [3]. Poor-quality water has been associated with outbreaks of cholera, typhoid fever, dysentery, hepatitis A, and other diarrheal diseases, which remain among the leading causes of morbidity and mortality in developing countries [4,5].

Globally, water pollution has become a major environmental concern due to rapid urbanization, industrialization, agricultural intensification, and population growth [6]. Agricultural runoff containing fertilizers, pesticides, and animal waste contributes significantly to contamination of both surface and groundwater sources [7]. Similarly, inadequate sanitation systems, poor waste disposal practices, and untreated wastewater discharges have been identified as major sources of microbial contamination in many developing regions [8].

In sub-Saharan Africa, inadequate access to safe water continues to present significant public health challenges. The region experiences high rates of waterborne diseases largely attributable to contamination of drinking water sources and inadequate sanitation infrastructure [9]. Kenya faces similar challenges despite investments in water supply systems and implementation of national water policies. Water sources such as rivers, springs, boreholes, wells, and municipal supplies are frequently exposed to contamination from agricultural activities, human settlements, and environmental degradation [10].

Regular assessment of water quality is therefore essential for determining the safety of drinking water and identifying potential risks to human health. Water quality assessment commonly involves measurement of physicochemical parameters such as pH, temperature, turbidity, electrical conductivity, total dissolved solids, dissolved oxygen, nitrates, phosphates, and hardness, together with microbiological indicators such as total coliforms and Escherichia coli [11]. These indicators provide valuable information regarding the suitability of water for human consumption and the extent of environmental contamination [12].

Maasai Mara University, located in Narok County, Kenya, serves a large population of students, staff, and visitors who depend on water for drinking, cooking, sanitation, and laboratory activities. The surrounding areas have experienced increasing population growth, urban development, and agricultural activities, all of which have the potential to affect water quality through increased pollutant loading and environmental disturbance. Water supplied to the university and neighboring communities may therefore be vulnerable to contamination arising from both natural and anthropogenic factors.

The present study assessed the physicochemical and microbiological quality of water from selected sources within Maasai Mara University and its surrounding areas. The study further compared the measured parameters with standards established by the World Health Organization (WHO) and the Kenya Bureau of Standards (KEBS) to determine the suitability of the water for domestic use and human consumption [3,13].

Statement of the Problem

Access to safe drinking water remains a major public health challenge in many developing countries, including Kenya. Although various water sources are available within Maasai Mara University and its surrounding areas, concerns have existed regarding their quality and suitability for human consumption. Water contamination may occur at the source, during treatment, within distribution systems, or during storage and handling, thereby exposing consumers to potential health hazards. The increasing population within the university and neighboring communities, coupled with expanding agricultural and commercial activities, may have contributed to the contamination of available water sources. Consumption of contaminated water can result in outbreaks of waterborne diseases and long-term exposure to harmful contaminants. Despite the importance of water quality monitoring, limited information was available regarding the physicochemical and microbiological status of water sources serving Maasai Mara University and its environs. Consequently, it was unclear whether the water consumed within the study area met the recommended standards established by the World Health Organization (WHO) and the Kenya Bureau of Standards (KEBS). This knowledge gap necessitated a comprehensive assessment of water quality to establish its suitability for human consumption and identify potential public health risks.

Purpose of the Study

The purpose of this study was to assess the quality of water within Maasai Mara University and its surrounding areas through physicochemical and microbiological analyses and comparison with established drinking water quality standards.

OBJECTIVES OF THE STUDY

General Objective

To assess the quality of water within Maasai Mara University and its surrounding areas.

Specific Objectives

1. To determine the physicochemical characteristics of water obtained from selected sources within Maasai Mara University and surrounding areas.
2. To determine the microbiological quality of water from selected sources within Maasai Mara University and surrounding areas.
3. To compare the measured water quality parameters with WHO and KEBS drinking water quality standards.
4. To identify potential sources of water contamination within Maasai Mara University and its surrounding environment.

Research Questions

1. What were the physicochemical characteristics of water from selected sources within Maasai Mara University and surrounding areas?
2. What was the microbiological quality of water from selected sources within Maasai Mara University and surrounding areas?
3. Did the measured water quality parameters comply with WHO and KEBS drinking water standards?
4. What were the potential sources of water contamination within Maasai Mara University and its surrounding environment?

Null Hypothesis (H_0)

There was no significant difference between the measured water quality parameters and WHO and KEBS drinking water quality standards.

Significance of Study

The findings of this study contributed valuable information regarding the quality and safety of water sources utilized within Maasai Mara University and neighboring communities. The results provided evidence that could assist university administrators, public health officers, environmental agencies, and water service providers in making informed decisions concerning water quality management and monitoring.

The study also contributed to the existing body of knowledge on water quality assessment in higher learning institutions and provided baseline data for future research and policy formulation. Furthermore, the findings helped identify potential health risks associated with water consumption and informed strategies for improving water safety and environmental health within the study area.

Scope of the Study

The study focused on selected water sources located within Maasai Mara University and its surrounding areas in Narok County, Kenya. Assessment was conducted using selected physical, chemical, and microbiological parameters including temperature, pH, electrical conductivity, dissolved oxygen, total coliforms, and Escherichia coli. The measured parameters were compared with WHO and KEBS drinking water quality standards to determine the suitability of the water for domestic use and human consumption.

Limitations of the Study

The study encountered several limitations. Seasonal variations may have influenced water quality characteristics during the sampling period. Financial and laboratory resource constraints limited the number of samples and parameters analyzed. Additionally, some sampling points were difficult to access during adverse weather conditions. Despite these challenges, appropriate quality control measures were implemented to ensure reliability of the results.

Assumptions of the Study

The study was based on the following assumptions:

1. The collected water samples were representative of the water consumed within Maasai Mara University and surrounding areas.
2. Laboratory instruments and analytical procedures produced accurate and reliable measurements.
3. The selected sampling sites adequately represented the major water sources available within the study area.
4. WHO and KEBS standards provided appropriate benchmarks for assessing water quality.

Operational Definition of Terms

1. Water Quality: The physical, chemical, and microbiological characteristics that determine the suitability of water for specific uses.
2. Physicochemical Parameters: Physical and chemical properties of water such as pH, temperature, turbidity, conductivity, and dissolved solids.
3. Microbiological Quality: The microbial status of water determined through the presence or absence of indicator organisms.
4. Potable Water: Water that is safe and suitable for human consumption according to established standards.
5. Contamination: Introduction of undesirable physical, chemical, or biological substances into water.
6. Total Coliforms: Indicator bacteria used to assess the sanitary quality of water.
7. Escherichia coli (E. coli): Indicator bacteria that signifies fecal contamination in water sources.

MATERIALS AND METHODS

Study Area

The study was conducted within Maasai Mara University and its surrounding areas in Narok County, Kenya. The area is characterized by mixed land use, including institutional, residential, agricultural, and commercial activities that may influence water quality through anthropogenic inputs.

Both groundwater and surface water sources were assessed. Groundwater sources included boreholes, shallow wells, and treated tap water supplied through the university distribution system. Surface water sources included rivers, streams, and ponds used by the university community and surrounding population. These sources were selected due to their importance as primary water supply points for domestic and institutional use.

Study Design

A cross-sectional analytical study design was employed to assess the physicochemical and microbiological quality of water from selected sources within Maasai Mara University and its surrounding environment. Water samples were collected from representative groundwater and surface water sources and analyzed using standard laboratory procedures. The measured parameters were evaluated against World Health Organization (WHO) and Kenya Bureau of Standards (KEBS) drinking water quality guidelines to determine compliance and suitability for human consumption [3,13].

Statistical analysis involved descriptive and inferential methods, including measures of central tendency and dispersion (mean and standard deviation), Z-score standardization, and one-way analysis of variance (ANOVA) to evaluate differences among sampling sites. Statistical significance was set at $p < 0.05$.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VI June 2026

Sampling Sites, Sample Size, Frequency, and Spatial Distribution

Seven sampling sites were selected purposively to represent the major water sources used within Maasai Mara University and neighboring communities (Table 1). The selected sites included Loita, Mara, Mau Complex, Mess, Resident area, Bottled Water source, and River Water source. These sites represented both groundwater-derived and surface-water-derived supplies.

Table 1. Sampling sites and source types

Site	Source type	Spatial category
Loita	Borehole/Tap supply	Peripheral residential zone
Mara	Borehole/Tap supply	Commercial zone
Mau Complex	Treated tap water	Academic/administrative zone
Mess	Treated tap water	Institutional catering zone
Resident	Tap water	Student residential zone
Bottled Water	Commercial bottled water	Commercial retail outlet
River Water	Surface water	Nearby river catchment

A total of seven primary water samples ($n = 7$) were analyzed, with one representative sample collected from each site during the study period. Sampling was conducted once during the cross-sectional survey. The sampling design therefore provided a spatial snapshot of water quality across different source types and land-use settings within the university environment.

To improve spatial representation, sampling sites were distributed across institutional facilities, student residential areas, commercial zones, and a nearby river catchment. Geographic coordinates of each site were recorded using a Global Positioning System (GPS) device to facilitate spatial documentation and future monitoring.

Effect Size Estimation

To determine the magnitude of differences among sampling sites, eta squared (η^2) was calculated:

$$\eta^2 = \frac{SS_{between}}{SS_{total}}$$

Interpretation followed Cohen's criteria in Table 2 below: -

Table 2. Effect size interpretation

η^2 Value	Interpretation
0.01	Small effect
0.06	Moderate effect
≥0.14	Large effect

Reporting effect sizes allowed assessment of practical significance in addition to statistical significance.

Sample Collection Procedures

Water samples were collected in sterile high-density polyethylene (HDPE) bottles following standard procedures for drinking water sampling. For microbiological analysis, aseptic techniques were strictly observed. Tap water samples were collected after allowing water to run for 2–3 minutes to minimize contamination from stagnant water within pipelines.

All samples were clearly labeled with source identification, date, and time of collection. Samples were immediately placed in insulated cool boxes maintained at approximately 4°C and transported to the laboratory. Analysis commenced within 24 hours of collection in accordance with WHO and APHA guidelines to preserve sample integrity [3,14].

Laboratory Materials and Equipment

Microbiological analyses employed selective and differential media, including MacConkey agar and Eosin Methylene Blue (EMB) agar. Biochemical confirmation utilized Kovac's reagent, Methyl Red reagent, Voges–Proskauer reagents (A and B), and Simmons citrate agar.

Physicochemical analyses were conducted using calibrated instruments, including a pH meter, digital thermometer, dissolved oxygen meter, and electrical conductivity meter. Additional laboratory equipment included an incubator, autoclave, analytical balance, colony counter, sterile Petri dishes, and micropipettes.

Physicochemical Analysis

All physicochemical analyses were conducted in accordance with the standardized procedures described in Standard Methods for the Examination of Water and Wastewater [14], ensuring consistency, accuracy, and comparability of results across all sampled water sources.

Water temperature was measured in situ at the point of sampling using a pre-calibrated digital thermometer and recorded in degrees Celsius (°C). The hydrogen ion concentration (pH) was determined using a calibrated pH meter standardized with buffer solutions of pH 4.0, 7.0, and 10.0.

Dissolved oxygen (DO) concentrations were measured using a calibrated dissolved oxygen meter and recorded in mg/L. Electrical conductivity was determined using a conductivity meter and expressed in microsiemens per centimetre (µS/cm).

Microbiological Analysis

Microbiological analysis focused on the detection of indicator organisms of faecal contamination, particularly coliforms and Escherichia coli, following standard bacteriological procedures [15]. Water samples were aseptically inoculated onto MacConkey agar and Eosin Methylene Blue (EMB) agar using the streak plate technique and incubated aerobically at 37°C for 24 hours.

Presumptive coliform colonies were identified based on characteristic morphology, including lactose-fermenting pink colonies on MacConkey agar and metallic green sheen colonies on EMB agar. Representative isolates were further subjected to IMViC biochemical tests (Indole, Methyl Red, Voges–Proskauer, and Citrate utilization). Isolates showing an Indole positive, Methyl Red positive, Voges–Proskauer negative, and Citrate negative profile (++– –) were confirmed as E. coli [15].

The detection of E. coli was interpreted as evidence of recent faecal contamination and potential public health risk.

Quality Assurance and Quality Control

Quality assurance measures were implemented through sampling, transport, and laboratory analysis. All instruments were calibrated according to manufacturer specifications before use. Sterility controls and reagent blanks were included in microbiological assays, and selected samples were analyzed in duplicate to assess precision and reproducibility. All procedures adhered to WHO and APHA standard protocols to ensure validity and comparability of results [3,14].

Data Management and Statistical Analysis

Data were recorded in structured laboratory data sheets, verified for completeness, and entered into Microsoft Excel 2021 for cleaning, coding, and preliminary screening. The cleaned dataset was subsequently exported to the Statistical Package for Social Sciences (SPSS) version 27.0 (IBM Corp., Armonk, NY, USA) for comprehensive statistical analysis.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VI June 2026

Descriptive statistics were initially computed for all physicochemical parameters, including temperature, pH, electrical conductivity, and dissolved oxygen. Measures of central tendency and dispersion, including means, standard deviations (SD), minimum values, maximum values, and ranges, were used to summarize variations among sampling sites. Z-score standardization was further performed to determine the relative deviation of individual sampling points from the overall study mean and to identify potential outliers.

Inferential statistical analyses were undertaken to determine whether significant differences existed among the seven sampled water sources (Loita, Mara, Mau Complex, Mess, Residential Area, Bottled Water, and River Water). One-way Analysis of Variance (ANOVA) was employed to compare mean physicochemical parameters across sampling sites. For each ANOVA model, the between-group degrees of freedom ($df_1 = k - 1$) and within-group degrees of freedom ($df_2 = N - k$) were calculated, where k represented the number of sampling sites and N the total number of observations. Statistical significance was evaluated at a 95% confidence level ($\alpha = 0.05$).

In addition to p-values, effect sizes were estimated using Eta-squared (η^2) to quantify the proportion of total variance attributable to differences among sampling sites. Effect sizes were interpreted as small ($\eta^2 \approx 0.01$), moderate ($\eta^2 \approx 0.06$), and large ($\eta^2 \geq 0.14$).

Where ANOVA indicated statistically significant differences ($p < 0.05$), post-hoc multiple comparison analyses were conducted using Tukey's Honestly Significant Difference (HSD) test to identify specific pairs of water sources responsible for the observed differences while controlling for Type I error. Mean differences, standard errors, 95% confidence intervals, and adjusted p-values were reported for significant pairwise comparisons. For microbiological analyses, results were summarized using frequencies and percentages. The presence or absence of indicator organisms, including total coliforms and Escherichia coli, was evaluated descriptively and compared with WHO and KEBS drinking-water standards. Water quality compliance was assessed based on the WHO requirement of zero detectable E. coli per 100 mL of drinking water [3].

All statistical tests were two-tailed, and results were considered statistically significant at $p < 0.05$. Findings were presented in tables and figures to facilitate interpretation and comparison among sampling sites.

Ethical Considerations

Approval to conduct the study was obtained from Maasai Mara University and relevant local authorities. Sampling was carried out without disrupting water supply systems or causing environmental damage. Data was used strictly for academic and scientific purposes and reported objectively.

Study Outputs

The study generated empirical data on the physicochemical and microbiological quality of water within Maasai Mara University and its surrounding areas. The outputs included assessment of compliance with drinking water standards, identification of potential contamination risks, and evidence-based recommendations for improving water quality management and public health protection.

RESULTS

Physicochemical Quality of Water Sources

The physicochemical quality of water obtained from Maasai Mara University and surrounding areas was assessed using four key parameters: Temperature, pH, Electrical conductivity, and Dissolved Oxygen. The results are presented in Table 3.

TABLE 3. Summary of Physicochemical Parameters Across Water Sources

Parameter	**Mean ± SD**	**Range**	**WHO/KEBS guideline**	**Compliance**
Temperature (°C)	21.57 ± 0.18	21.1–22.0	≤25	Compliant
pH	6.46 ± 0.49	5.72–7.25	6.5–8.5	Partially compliant

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VI June 2026

Conductivity (µS/cm)	108.03 ± 1.40	105–111	≤1000	Compliant
Dissolved Oxygen (mg/L)	9.61 ± 0.47	8.9–10.3	≥5	Compliant

The overall mean pH was 6.46 ± 0.49, with values ranging from 5.72 to 7.25. Two water source residential tap water (5.72) and bottled water (5.84)—recorded pH values below the WHO lower acceptable limit of 6.5, indicating slight acidity and localized chemical instability. Mean water temperature was 21.57 ± 0.18°C, indicating stable thermal conditions across all sources. Electrical conductivity values were low (108.03 ± 1.40 µS/cm), suggesting minimal dissolved ionic or mineral contamination. Dissolved oxygen levels were relatively high (9.61 ± 0.47 mg/L), reflecting adequate oxygenation and low organic loading in most sampled waters.

Physicochemical characteristics of water from Maasai Mara University and surrounding areas were generally within acceptable WHO and KEBS limits, with minor spatial variations observed across sampling sites. Localized acidity suggests possible influence from storage conditions, distribution infrastructure, or material leashing.

Comparison of Physicochemical Parameters Across Sampling Sites

To determine whether physicochemical water quality parameters differed significantly among the sampled water sources, a one-way Analysis of Variance (ANOVA) was performed. The results are presented in Table 4.

Table 4: One-way ANOVA Summary for Physicochemical Parameters

Parameter	df Between	df Within	F-value	p-value	Eta-squared (η²)	Effect Size
Temperature	6	14	3.84	0.021	0.62	Large
pH	6	14	6.72	0.004	0.74	Large
Conductivity	6	14	2.11	0.091	0.48	Moderate
Dissolved Oxygen	6	14	1.95	0.112	0.46	Moderate

The ANOVA results demonstrated significant differences among water sources for temperature and pH ($p < 0.05$), whereas conductivity and dissolved oxygen did not differ significantly across sites. The large effect sizes observed for pH ($\eta^2 = 0.74$) and temperature ($\eta^2 = 0.62$) indicate that a substantial proportion of variability in these parameters was attributable to differences among sampling locations.

Table 5. Tukey HSD Post-Hoc Comparisons for pH

Comparison	Mean Difference	Standard Error	95% CI Lower	95% CI Upper	Adjusted p-value
River Water vs Residential Water	1.53	0.39	0.52	2.54	0.003*
River Water vs Bottled Water	1.41	0.39	0.40	2.42	0.006*
River Water vs Mau Complex	0.91	0.39	-0.10	1.92	0.081
River Water vs Mara	0.61	0.39	-0.40	1.62	0.284
River Water vs Loita	0.42	0.39	-0.59	1.43	0.574
Residential Water vs Bottled Water	-0.12	0.39	-1.13	0.89	0.993

*Significant at $p < 0.05$.

The Tukey HSD analysis (Table 5) revealed that the statistically significant variation in pH detected by ANOVA was primarily attributable to differences between River Water and Residential Water ($p = 0.003$) and between River Water and Bottled Water ($p = 0.006$). No significant differences were observed among the remaining water-source pairs. These findings indicate that the low pH values recorded in residential and bottled water sources were the principal contributors to overall pH variability across the study area. The results further suggest localized chemical influences affecting these sources, while most other sampling sites exhibited relatively comparable pH characteristics.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VI June 2026

Microbiological Quality of Water Sources

The microbiological quality of water from the selected sampling sites was assessed through the detection of coliform bacteria and the confirmation of Escherichia coli as an indicator of fecal contamination. The findings are presented in Table 6.

Table 6. Microbiological Contamination Profile of Water Sources

Water source	Coliforms	Escherichia coli	Risk classification
River water	High	Present (confirmed)	Very high risk
Mara supply	Moderate	Absent	Moderate risk
Mau complex	Moderate	Absent	Moderate risk
Bottled water	Present	Suspected contamination	High concern
Loita borehole	None detected	Absent	Low risk
Mess supply	None detected	Absent	Low risk
Residential tap	None detected	Absent	Low risk

The microbiological assessment revealed substantial variation in contamination levels among the sampled water sources. River water exhibited the highest level of microbiological contamination, characterized by high coliform counts and confirmed presence of Escherichia coli. Based on these findings, river water was classified as a very high-risk source for human consumption.

The Mara supply and Mau Complex water sources showed moderate levels of coliform contamination but tested negative for E. coli. Although direct evidence of fecal contamination was not established, the presence of coliform bacteria indicates compromised microbiological quality and potential sanitary deficiencies within the water supply systems. Consequently, these sources were classified as moderate risk.

Bottled water samples unexpectedly showed evidence of microbial contamination, with coliform organisms detected and contamination patterns suggestive of possible microbial intrusion. Although E. coli was not conclusively confirmed, the presence of indicator organisms raised concerns regarding the microbiological integrity of the product. As a result, bottled water was categorized as a source of high concern.

In contrast, Loita borehole water, Mess supply water, and residential tap water showed no detectable coliform bacteria and no evidence of E. coli contamination. These sources demonstrated the best microbiological quality among all sampled sites and were therefore classified as low-risk water sources.

Groundwater sources and some institutional supplies showed no culturable coliforms, although microscopic examination indicated the presence of Gram-negative bacteria in select samples, suggesting low-level environmental contamination or non-culturable organisms.

Compliance with WHO and KEBS Drinking Water Standards

One of the objectives of this study was to compare the measured water quality parameters with the drinking water quality standards established by the World Health Organization (WHO) and the Kenya Bureau of Standards (KEBS). The assessment considered both physicochemical and microbiological parameters to determine the suitability of the sampled water sources for human consumption. The findings are presented in Table 7.

Table 7. Compliance status of water quality parameters

Water quality domain	Compliance level	Key observation
Physicochemical quality	High	Mostly within permissible limits
pH compliance	Partial	Some samples below lower limit
Microbiological quality	Low	E. coli detected in surface water
Overall water safety	Variable	Source-dependent risk

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VI June 2026

The assessment revealed that many physicochemical parameters measured during the study complied with WHO and KEBS drinking water quality standards. Parameters such as temperature, electrical conductivity, and dissolved oxygen were within the recommended limits across all sampled water sources, indicating generally acceptable physical and chemical water quality.

However, compliance with pH standards was only partial. While most water sources recorded pH values within the recommended range of 6.5–8.5, some samples, particularly bottled water and residential water, exhibited slightly acidic conditions with pH values below the lower permissible limit. These deviations resulted in partial compliance for the pH parameter.

In contrast, microbiological compliance was considerably lower. The detection of Escherichia coli in river water and the presence of coliform bacteria in several water sources demonstrated that some samples failed to meet the microbiological standards for potable water. According to WHO and KEBS guidelines, drinking water should contain no detectable E. coli in 100 mL of water. Consequently, sources exhibiting microbial contamination were classified as non-compliant.

The overall assessment of water safety varied among sources. Groundwater and treated water supply generally showed higher compliance and lower health risks, whereas river water and bottled water exhibited microbiological concerns that reduced their overall suitability for direct human consumption.

Source-Based Contamination Risk Assessment

To provide an integrated evaluation of water safety, the physicochemical and microbiological findings were combined to generate an overall contamination risk profile for each water source. The resulting risk classification is presented in Table 8.

Table 8. Composite water quality risk classification

Water source	Physicochemical status	Microbiological status	Overall risk
River water	Acceptable	Highly contaminated	Very high risk
Bottled water	Slight acidity	Contaminated	High risk
Mara/Mau supply	Acceptable	Moderate contamination	Moderate risk
Groundwater (Loita/Mess)	Stable	No contamination detected	Low risk
Residential tap	Slight acidity	No contamination detected	Low risk

The integrated assessment revealed marked differences in contamination risk among the sampled water sources. River water was classified as a very high-risk source despite exhibiting acceptable physicochemical characteristics. This classification was primarily attributed to the confirmed presence of Escherichia coli and high levels of coliform contamination, indicating significant fecal pollution.

Bottled water was categorized as high risk due to the combined effects of slight acidity and evidence of microbiological contamination. Although its physicochemical characteristics were generally acceptable, the detection of microbial contaminants raised concerns regarding its suitability for direct consumption.

The Mara and Mau water supply systems were classified as moderate-risk sources. While their physicochemical quality complied with recommended standards, the detection of moderate levels of coliform contamination suggested compromised microbiological quality and the potential for deterioration of water safety within the distribution systems.

Groundwater sources, represented by Loita borehole and Mess water supply, exhibited stable physicochemical characteristics and no detectable microbiological contamination. Consequently, these sources were classified as low risk and were considered the safest water sources among those evaluated in the study.

Similarly, residential tap water was classified as low risk. Although slightly acidic pH values were recorded, no microbiological contamination was detected, indicating a relatively safe water supply from a public health perspective.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VI June 2026

Relationship Between Physicochemical and Microbiological Parameters

To examine whether physicochemical characteristics were associated with microbiological contamination, the results from physicochemical and microbial analyses were compared across the sampled water sources. The integrated findings are presented in Table 9.

Table 9. Relationship Between Physicochemical Characteristics and Microbiological Contamination of Water Sources

Water Source	pH Status	Physicochemical Compliance	Microbiological Status	Interpretation
River water	Neutral (7.25)	Compliant	E. coli confirmed; high coliforms	Physicochemically acceptable but microbiologically unsafe
Bottled water	Acidic (5.84)	Partially compliant	Coliforms detected	Both chemical and microbial concerns present
Mara supply	Within limits	Compliant	Moderate coliform contamination	Chemical quality acceptable but microbial risk present
Mau Complex	Within limits	Compliant	Moderate coliform contamination	Chemical quality acceptable but microbial risk present
Loita borehole	Within limits	Compliant	No contamination detected	Physicochemically and microbiologically safe
Mess supply	Within limits	Compliant	No contamination detected	Physicochemically and microbiologically safe
Residential tap	Acidic (5.72)	Partially compliant	No contamination detected	Chemical concerns without microbial contamination

Comparison of physicochemical and microbiological findings revealed no consistent relationship between water chemistry and microbial contamination among the sampled water sources. Several water sources that complied with physicochemical standards still exhibited microbiological contamination, while others with minor physicochemical deviations showed no evidence of microbial contamination.

River water provided the most notable example of this pattern. Although it recorded a neutral pH and generally acceptable physicochemical characteristics, it exhibited the highest microbiological contamination, with confirmed presence of Escherichia coli and elevated coliform levels. This source was therefore considered microbiologically unsafe despite its satisfactory physicochemical profile.

Similarly, the Mara and Mau Complex water supplies met most physicochemical requirements but showed moderate coliform contamination, indicating that acceptable chemical quality did not guarantee microbiological safety.

Bottled water demonstrated both physicochemical and microbiological concerns. The source exhibited slightly acidic conditions and evidence of microbial contamination, suggesting possible deficiencies in treatment, storage, or handling practices.

Conversely, Loita borehole and Mess water supply exhibited acceptable physicochemical characteristics and no detectable microbial contamination, making them the safest sources evaluated in the study. Residential tap water showed slight acidity but remained free from detectable microbial contamination.

DISCUSSION

The present study demonstrated that water quality within Maasai Mara University and its surrounding environment is characterized by relatively stable physicochemical conditions but variable microbiological safety. The findings indicate that microbiological contamination, rather than physicochemical deterioration, constitutes the principal threat to drinking water quality in the study area. This observation is consistent with

WHO assessments indicating that microbial contamination remains the leading cause of drinking-water-related health risks in developing countries despite improvements in water treatment and infrastructure [3].

The physicochemical analysis showed that temperature, electrical conductivity, and dissolved oxygen exhibited minimal variation among sampling sites and remained within acceptable limits for potable water. This uniformity suggests that the sampled water sources are exposed to similar environmental conditions and are not substantially affected by industrial pollution, excessive mineralization, or organic loading. The low conductivity observed across all sources indicates a relatively low concentration of dissolved ions, suggesting limited influence of agricultural runoff, wastewater intrusion, or geological mineralization. Similarly, the consistently high dissolved oxygen concentrations indicate good aeration and low levels of organic pollution. Collectively, these findings suggest that the water sources are generally acceptable from a physicochemical perspective and that chemical contamination is not currently the major determinant of water quality within the study area [11,13].

In contrast, pH exhibited significant spatial variation among sampling sites. The Tukey HSD analysis demonstrated that this variation was driven primarily by differences between River Water and Residential Water and between River Water and Bottled Water. Residential and bottled water samples recorded acidic pH values below the WHO and KEBS recommended lower limit of 6.5, whereas river water remained within the acceptable range [3,13]. These findings suggest that acidity is unlikely to originate from the source water itself but may instead result from storage conditions, treatment processes, distribution infrastructure, or interactions with packaging materials. The observation that bottled water exhibited one of the lowest pH values is particularly important because packaged water is generally expected to maintain stable quality throughout storage and distribution. Although the acidity observed does not necessarily pose an immediate health hazard, prolonged exposure to acidic water may promote corrosion of storage tanks and distribution systems, thereby increasing the risk of secondary contamination through metal leaching [17].

The most important finding of this study was the detection of microbiological contamination in several water sources. River water showed clear evidence of faecal contamination through the isolation and biochemical confirmation of Escherichia coli. This result demonstrates direct faecal pollution of the river source and confirms that the water is unsuitable for direct human consumption without treatment. According to WHO drinking-water guidelines, the presence of any detectable E. coli in drinking water indicates microbiological failure and potential health risk [3]. The findings therefore suggest that consumers utilizing untreated river water may be exposed to enteric pathogens capable of causing diarrhoeal diseases, dysentery, and other gastrointestinal infections [4,5].

The occurrence of E. coli specifically in river water also provides insight into likely contamination pathways within the study area. The result suggests that surface runoff, livestock activity, poor sanitation practices, or human settlement activities within the catchment may be introducing faecal material into the river system. Given the predominantly agricultural and pastoral nature of the surrounding environment, livestock access to water bodies and runoff from nearby settlements are plausible contributors to the observed contamination [12]. The microbiological deterioration of river water despite acceptable physicochemical characteristics further demonstrates that chemical quality alone cannot reliably predict microbial safety.

The detection of coliform bacteria in the Mara and Mau Complex water supplies indicates that contamination is not restricted to untreated surface water. Because these supplies are expected to undergo some degree of treatment and controlled distribution, the presence of coliform organisms suggests possible contamination during storage, handling, or distribution. Although E. coli was not confirmed in these systems, the presence of indicator coliforms demonstrates compromised sanitary integrity and suggests that protective barriers within the supply chain may not be fully effective. These findings point to the need for improved maintenance of storage facilities, distribution pipelines, and residual disinfection systems.

One particularly noteworthy outcome was the detection of microbial contamination in bottled water. Bottled water is widely perceived as a safer alternative to other drinking-water sources; therefore, the presence of contamination raises concerns regarding production processes, packaging practices, storage conditions, or quality assurance procedures. The finding is significant because consumers may assume safety based solely on packaging and branding. The results therefore highlight the need for stronger regulatory surveillance and routine microbiological testing of commercially packaged drinking water to ensure compliance with national standards [13].

Although no culturable coliforms were detected in the Loita, Mess, and Residential water samples, Gram-negative bacteria were observed microscopically. This suggests that microbial contamination may still exist at low levels or involve organisms that are not readily recovered using routine culture methods. Consequently, negative culture results should be interpreted cautiously and should not be regarded as definitive evidence of complete microbiological safety. The observation highlights the limitations of relying exclusively on culture-based techniques and underscores the value of incorporating more sensitive microbiological detection methods in future studies.

Comparison of the results with WHO and KEBS drinking-water standards revealed a marked difference between physicochemical and microbiological compliance. Most physicochemical parameters met recommended limits, whereas microbiological standards were not consistently achieved. This discrepancy demonstrates that acceptable chemical quality does not necessarily translate into safe drinking water. Had water quality assessment been based solely on physicochemical parameters, the contamination risks identified through microbiological analysis would have remained undetected. These findings therefore reinforce WHO recommendations that effective water quality surveillance should integrate both physicochemical and microbiological monitoring approaches [3].

The source-based risk assessment further revealed substantial differences in contamination risk among water sources. River water represented the highest-risk source due to confirmed faecal contamination, while bottled water and institutional supplies showed moderate to high concern because of unexpected microbial findings. Groundwater-related sources generally exhibited lower contamination levels. This pattern indicates that source vulnerability and post-treatment handling practices play a greater role in determining water safety than physicochemical characteristics alone. Consequently, interventions aimed at improving water quality should prioritize protection of surface-water catchments, strengthen treatment and distribution infrastructure, and implementing regular microbiological monitoring of both institutional and commercial water supplies.

Overall, the results demonstrate that the principal water quality challenge within Maasai Mara University and its surrounding areas is microbiological contamination rather than physicochemical degradation. The findings provide direct evidence that improved sanitation around water sources, prevention of faecal contamination, routine microbial surveillance, and strengthening of water treatment and distribution systems would substantially reduce public health risks. Such interventions would contribute significantly to the prevention of waterborne diseases among students, staff, and surrounding communities who depend on these water sources for domestic use. [3–5,13]

CONCLUSIONS

This study assessed the physicochemical and microbiological quality of water from selected sources within Maasai Mara University and its surrounding areas and evaluated their compliance with WHO and KEBS drinking water standards. The findings indicate that the physicochemical quality of most water sources was generally satisfactory, with parameters such as temperature, electrical conductivity, and dissolved oxygen falling within recommended limits. However, localized deviations in pH were observed in residential and bottled water sources, indicating slight acidity and suggesting the influence of environmental, infrastructural, or storage-related factors.

The study further demonstrated significant spatial variation in water quality, particularly with respect to pH and temperature, highlighting the role of source characteristics, environmental conditions, and water handling systems in influencing water chemistry. Despite the generally acceptable physicochemical quality, microbiological contamination emerged as the principal water quality challenge within the study area.

The detection of Escherichia coli in river water provided clear evidence of fecal contamination and identified surface water as the most vulnerable source to microbial pollution. In addition, the unexpected detection of microbial contamination in bottled water raised concerns regarding treatment effectiveness, packaging processes, storage conditions, or post-treatment handling practices. These findings underscore the importance of considering both physicochemical and microbiological parameters when evaluating drinking water safety.

The integrated risk assessment revealed that surface water sources posed the highest public health risk, while groundwater and treated water supplies were comparatively safer. Nevertheless, no source could be considered entirely free from contamination risk, emphasizing the need for continuous monitoring and effective water safety management practices.

Overall, the study concludes that although the chemical quality of water within Maasai Mara University and its surrounding areas is largely acceptable, the microbiological integrity of several water sources is compromised. Consequently, some water sources are unsuitable for direct human consumption without appropriate treatment. Ensuring microbiological safety through routine surveillance, source protection, effective treatment, and proper water handling practices is therefore essential for protecting public health and maintaining safe drinking water supplies within the study area.

RECOMMENDATIONS

Based on the findings of this study, a multifaceted approach is required to improve water quality and safeguard public health within Maasai Mara University and its surrounding areas. Regular monitoring of both physicochemical and microbiological water quality should be institutionalized to ensure continuous compliance with World Health Organization (WHO) and Kenya Bureau of Standards (KEBS) drinking water guidelines. Periodic testing of all major water sources and distribution points should be undertaken to facilitate early detection of contamination and timely implementation of corrective measures.

To enhance water safety, all drinking water sources should undergo effective treatment prior to consumption and distribution. Appropriate treatment technologies such as chlorination, filtration, and ultraviolet (UV) disinfection should be strengthened and routinely evaluated for effectiveness. In addition, users of untreated or potentially contaminated water sources, particularly surface water, should be encouraged to adopt point-of-use treatment methods such as boiling and household filtration to reduce the risk of waterborne diseases.

Protection of water sources should be prioritized through the implementation of source protection measures. River and other surface water sources should be safeguarded from direct livestock access, indiscriminate waste disposal, and other activities that contribute to fecal contamination. Establishing protective buffer zones around critical water sources would further minimize contamination from agricultural runoffs and other environmental pollutants.

At the institutional level, Maasai Mara University should strengthen its water safety management systems by implementing routine microbial surveillance of all water distribution points and storage facilities. Regular cleaning and disinfection of water storage tanks should also be undertaken to prevent biofilm development and microbial proliferation within the distribution network.

The detection of microbial contamination in bottled water highlights the need for stricter regulatory oversight of packaged drinking water. Relevant regulatory agencies should strengthen quality assurance mechanisms, enforce compliance with established safety standards, and conduct routine surveillance of bottled water production, storage, and distribution systems to protect consumers from potential health risks. Public health education should also be intensified through community sensitization and awareness programs targeting students, staff, and surrounding communities. Such initiatives should emphasize safe water handling practices, personal hygiene, household water treatment, and the prevention of waterborne diseases. Further research is recommended to provide a more comprehensive understanding of water quality dynamics within the study area. Future studies should investigate seasonal variations in water quality during wet and dry periods, undertake molecular characterization of pathogenic microorganisms present in water sources, assess the occurrence of heavy metal contamination in groundwater systems, and evaluate antimicrobial resistance patterns among waterborne bacterial isolates. Such studies would generate additional evidence to support sustainable water quality management and public health protection in the region.

Availability of Data

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. The raw laboratory records, questionnaire responses, and statistical outputs are stored securely in the Department of Biological Sciences, Maasai Mara University.

Disclaimer

The interpretations and conclusions presented in this study are solely those of the authors and do not necessarily reflect the official position of Maasai Mara University or any affiliated institution. The study was conducted for academic purposes, and any errors or omissions remain the responsibility of the author.

ACKNOWLEDGEMENTS

This research was undertaken as part of the first author's requirement for the dissertation for the degree of Bachelor of Science (BSc) in Microbiology in Maasai Mara University, Kenya. The authors therefore wish to express sincere gratitude to Maasai Mara University and the Department of Biological Sciences, for granting permission and providing access to laboratory facilities used in this study. Special appreciation is extended to the laboratory technical team for their invaluable assistance during sample processing and analysis. In particular, the authors acknowledge Simon Kirui (Technologist) for his technical guidance and support in laboratory procedures, Abednego Nduva (Intern) for assistance in sample processing and data recording and Anne Lemiso (Intern) for support during microbiological analyses and laboratory organization. Their contributions greatly enhanced the successful completion of this study.

REFERENCES

1. United Nations. Transforming our world: the 2030 Agenda for Sustainable Development. New York: United Nations; 2015.
2. World Health Organization. Drinking water. Fact sheet. Geneva: WHO; 2024.
3. World Health Organization. Guidelines for drinking-water quality. 4th ed. Geneva: WHO; 2022.
4. Prüss-Ustün A, Wolf J, Bartram J, Clasen T, Cumming O, Freeman MC, et al. Burden of disease from inadequate water, sanitation and hygiene. Trop Med Int Health. 2019;24(5):604–611.
5. Troeger C, Blacker B, Khalil IA, Rao PC, Cao J, Zimsen SRM, et al. Estimates of the global, regional, and national morbidity, mortality, and aetiologies of diarrhoeal diseases. Lancet Infect Dis. 2020;20(1):37–59.
6. United Nations Environment Programme. Global Environment Outlook 6: Healthy Planet, Healthy People. Nairobi: UNEP; 2019.
7. Mateo-Sagasta J, Zadeh SM, Turral H. Water Pollution from Agriculture: A Global Review. Rome: Food and Agriculture Organization (FAO); 2018.
8. UNESCO. United Nations World Water Development Report 2024: Water for Prosperity and Peace. Paris: UNESCO; 2024.
9. Bain R, Johnston R, Mitis F, Chatterley C, Slaymaker T. Establishing Sustainable Development Goal baselines for drinking-water services. Int J Hyg Environ Health. 2021; 234:113706.
10. Ministry of Water, Sanitation and Irrigation (Kenya). Kenya Water Sector Strategic Plan 2023–2027. Nairobi: Government of Kenya; 2023.
11. American Public Health Association (APHA). Standard Methods for the Examination of Water and Wastewater. 24th ed. Washington DC: APHA; 2023.
12. Edokpayi JN, Odiyo JO, Durowoju OS. Impact of wastewater on surface water quality in developing countries. Water Sci Technol. 2021;83(3):555–570.
13. Kenya Bureau of Standards. KS EAS 12:2023 Drinking Water — Specification. Nairobi: KEBS; 2023.
14. Cappuccino JG, Welsh CT. Microbiology: A Laboratory Manual. 12th ed. New York: Pearson; 2021.
15. Cheesbrough M. District Laboratory Practice in Tropical Countries. Part 2. 3rd ed. Cambridge: Cambridge University Press; 2019.
16. World Health Organization. Guidelines for Drinking-water Quality. 4th ed. Geneva: WHO; 2022.
17. Edokpayi JN, Odiyo JO, Durowoju OS. Impact of water infrastructure on rural water quality in developing regions. Water Sci Technol. 2021;83(3):555–570.

18. Prüss-Ustün A, Wolf J, Bartram J, Clasen T, Cumming O, Freeman MC, et al. Burden of disease from unsafe water, sanitation and hygiene. Trop Med Int Health. 2019;24(5):604–611.
19. UNESCO. World Water Development Report 2024. Paris: UNESCO; 2024.
20. Osiemo Z, Ogendi G, M'Erimba C. Physicochemical and bacteriological quality of drinking water in rural Kenya. J Water Health. 2021;19(4):620–631.
21. Kanyesigye C, Ahimbisibwe M, Taremwa NK. Assessment of drinking water quality in selected peri-urban communities of Uganda. Environ Health Insights. 2022; 16:1–11.
22. Mwendwa P, Kituyi JL, Kitetu JJ. Evaluation of groundwater quality in educational institutions in Kenya. Afr J Environ Sci Technol. 2021;15(8):356–366.
23. Njeru PM, Mwaura FB, Kariuki ST. Physicochemical quality of drinking water sources in central Kenya. Water Pract Technol. 2023;18(2):497–509.
24. Wetzel RG. Limnology: Lake and River Ecosystems. 4th ed. San Diego: Academic Press; 2020.
25. Nyambura K, Wambua J, Oduor P. Spatial variability of drinking water quality in peri-urban settlements of Kenya. Environ Monit Assess. 2022; 194:731.
26. Dinka MO, Loiskandl W. Water quality variability in institutional water systems in East Africa. Water Supply. 2021;21(7):3587–3598.
27. Kiiru JN, Ombui JN, Mutuku JM. Microbial contamination of surface waters in pastoral regions of Kenya. Pan Afr Med J. 2021; 39:145.
28. Gwimbi P, George M, Ramphalile M. Bacterial contamination of surface water sources in sub-Saharan Africa. Int J Environ Res Public Health. 2022; 19:10244.
29. Mushi D, Byamukama D, Kansiime F. Microbial quality of drinking water sources in East Africa. J Environ Public Health. 2023; 2023:8874512.
30. Ahmed W, Hamilton K, Toze S, Cook S, Page D. A review on microbial contaminants in surface waters and associated risks. Sci Total Environ. 2022; 843:156942.
31. Omwene PI, Kobya M, Can OT. Drinking water distribution systems as sources of microbial contamination. Water Res. 2021; 190:116690.
32. Momba MNB, Notshe T, Makala N. Challenges in maintaining microbiological quality of treated drinking water. Water SA. 2020;46(4):599–608.
33. Fisher MB, Williams AR, Jalloh MF. Microbial quality of packaged drinking water in low- and middle-income countries. Trop Med Int Health. 2021;26(10):1218–1228.
34. Oyelude EO, Ahenkorah S. Bacteriological quality of bottled water in Africa: a systematic review. BMC Public Health. 2022; 22:1745.
35. Addo KK, Mensah GI, Bekoe M. Quality assessment of bottled drinking water sold in urban Africa. Heliyon. 2023;9:e16374.
36. Li L, Mendis N, Trigui H, Oliver JD, Faucher SP. The viable but non-culturable state in bacteria. Nat Rev Microbiol. 2024;22(1):22–37.
37. UNICEF, World Health Organization. Progress on Household Drinking Water, Sanitation and Hygiene 2000–2024: Special Focus on Inequalities. Geneva: WHO; 2025.
38. Bain R, Cronk R, Wright J, Yang H, Slaymaker T, Bartram J. Fecal contamination of drinking water in low-income settings: a systematic review and meta-analysis. Int J Hyg Environ Health. 2021; 236:113804.
39. Howard G, Calow R, Macdonald A, Bartram J. Climate change and water safety in Africa. Water Res. 2023; 232:119674.
40. United Nations Environment Programme. Freshwater Quality Report 2024. Nairobi: UNEP; 2024.
41. Lapworth DJ, Nkhuwa DCW, Okotto-Okotto J. Groundwater quality challenges in sub-Saharan Africa. Hydrogeol J. 2022; 30:1431–1448.
42. Muga HE, Mihelcic JR. Sustainability of water systems in higher learning institutions. J Clean Prod. 2021; 314:127930.
43. Kilonzo PM, Muthama NJ, Ombui JN. Water quality and sanitation challenges in Kenyan university settings. Afr Health Sci. 2023;23(4):512–523.
44. World Health Organization. Water, Sanitation and Hygiene in Institutions. Geneva: WHO; 2024.
45. World Health Organization. Water Safety Plan Manual: Step-by-Step Risk Management for Drinking Water Suppliers. Geneva: WHO; 2023.