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(RESEARCH ARTICLE)

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Physicochemical and microbiological quality of improved well water in Nkol-Afamba subdivision (Centre Region, Cameroon)

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Abstract

Introduction: In peri-urban areas of Cameroon, the use of improved wells remains frequent due to insufficient continuous access to the public drinking water network. This study aimed to evaluate the physicochemical and microbiological quality of improved well water in Nkol-Afamba Subdivision (Centre Region, Cameroon).

Methods: An analytical cross-sectional study was conducted from October 2023 to June 2024 in the Lada I area. Thirty-two accessible improved wells were exhaustively included. Physicochemical parameters were measured using pH-metry and spectrophotometry. Microbiological analyses were performed using membrane filtration and inoculation on selective media. Factors associated with microbiological non-compliance were identified using binary logistic regression. Statistical significance was set at $p < 0.05$.

Results: The pH ranged from 6.5 to 8.5 and conductivity from 16 to 172 µS/cm. Nitrates, nitrites, and heavy metals were not detected. All physicochemical parameters complied with national standards. However, 90.6% of samples were microbiologically non-compliant. Total and fecal coliforms were detected in 31 of the 32 wells. Escherichia coli was present in 15.6% of wells. A latrine–well distance < 15 m was significantly associated with contamination (OR = 4.3; 95% CI: 1.1–16.8; $p = 0.03$).

Conclusion: Despite satisfactory physicochemical quality, the high microbiological contamination exposes the population to significant health risks. Strengthening sanitation measures and regular monitoring is recommended.

Keywords: Well Water; Microbiological Contamination; Coliforms; Cameroon

1. Introduction

Access to safe drinking water remains a critical public health concern, particularly in rapidly urbanizing areas of developing countries. In Cameroon, urban centers such as Yaoundé face increasing pressure on their water resources due to population growth, unplanned urban expansion, and insufficient sanitation infrastructure. Groundwater is a major source of drinking water for many households, yet its quality is often compromised by anthropogenic activities, including improper waste disposal and inadequate faecal sludge management [1,2,3]. Contamination by pathogens and chemical pollutants poses significant health risks, including gastrointestinal diseases and long-term effects from nitrates and other chemical constituents [4,5]. Despite the existence of national and international guidelines for drinking water quality [6,7], studies indicate that many households rely on water that does not meet these standards. Regular

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monitoring of physicochemical and bacteriological parameters, coupled with improvements in sanitation practices, is therefore essential to ensure public health safety [8,9]. Understanding the interaction between urban hygiene behaviors and groundwater contamination is crucial for developing effective interventions and sustainable water management strategies in Yaoundé and similar contexts. This study synthesizes current evidence on water quality and sanitation practices to highlight key risks and potential mitigation measures.

2. Materials and Methods

2.1. Study Design and Period

An analytical cross-sectional study was conducted from October 10, 2023, to June 30, 2024.

2.2. Study Site and Population

The study took place in the Lada I area, Nkol-Afamba Subdivision (Centre Region, Cameroon).

2.3. Sampling

All accessible improved wells in the area during the study period were included, totaling 32 wells. Collected variables included well depth, latrine–well distance, frequency of water treatment, and sanitary condition.

2.4. Physicochemical Analyses

Parameters measured included pH, conductivity, total dissolved solids (TDS), turbidity, hardness, sodium, chlorides, nitrates, nitrites, and heavy metals. Analyses followed standard methods described by Rodier et al. [7] and Hem [8].

2.5. Microbiological Analyses

Microbiological analyses focused on total aerobic mesophilic flora (TAMF), total coliforms, fecal coliforms, Escherichia coli, Staphylococcus spp., Salmonella spp., and yeasts. Results were interpreted according to WHO recommendations [2] and Cameroonian Standard NC 2867 for drinking water [9].

2.6. Statistical Analysis

Data were analyzed using Microsoft Excel. Quantitative variables were expressed as mean ± standard deviation. Associations were assessed using the Chi-square test. Binary logistic regression including variables significant in bivariate analysis was performed to avoid model overfitting. Statistical significance was set at $p < 0.05$.

2.7. Ethical Considerations

The study was conducted with verbal consent from well owners. Collected data were anonymized and used solely for scientific purposes.

3. Results

3.1. Well Characteristics

Among the 32 wells studied, 34.4% had a depth < 20 m, and 18.7% were located < 15 m from a latrine. Irregular treatment was observed in 5.3% of cases.

3.2. Physicochemical Parameters

Table 1 Physicochemical Parameters

Parameter	Mean ± SD	Min	Max	Standard
pH	7.28 ± 0.79	6.5	8.5	6.5–8.5
Conductivity (µS/cm)	58.3 ± 46.7	16	172	< 1000
Turbidity (NTU)	< 5	-	-	< 5

The mean pH was 7.28 ± 0.79, and the mean conductivity was 58.3 ± 46.7 µS/cm. Nitrates, nitrites, and heavy metals were not detected (table 1). All physicochemical parameters complied with national standards.

3.3. Microbiological Parameters

In contrast, 29 of 32 samples (90.6%) were microbiologically non-compliant. Total and fecal coliforms were present in 31 wells. Escherichia coli was detected in 5 wells (15.6%).

3.4. Multivariate Analysis

Table 2 Multivariate analysis

Variable	OR	95% CI	p
Distance < 15 m	4.3	1.1–16.8	0.03
Depth < 20 m	3.1	1.0–9.4	0.04
Irregular treatment	2.6	-	0.08

A latrine–well distance < 15 m was significantly associated with microbiological contamination (OR = 4.3; 95% CI: 1.1–16.8; p = 0.03). Shallow depth (< 20 m) was also associated with higher risk (OR = 3.1; 95% CI: 1.0–9.4; p = 0.04) (table 2).

4. Discussion

The findings from previous studies indicate a strong link between urban sanitation practices and groundwater quality in Yaoundé. Improper disposal of faecal sludge and inadequate wastewater management contribute to elevated levels of microbial contamination, posing immediate health risks to urban populations [2,8]. Bacteriological analyses consistently reveal the presence of faecal coliforms and other pathogens in wells and boreholes, highlighting the vulnerability of groundwater to human activities [1,3]. Chemical parameters, including nitrates, also frequently exceed recommended thresholds, suggesting that agricultural runoff and domestic waste significantly impact water quality [4,5]. These contaminants can have chronic health effects, particularly in children, emphasizing the urgent need for monitoring and regulation [4].

Despite established standards and guidelines by WHO and ANOR [6,7], compliance remains inconsistent due to limited infrastructure, lack of community awareness, and financial constraints. Studies in Yaoundé neighborhoods demonstrate that household-level interventions, such as proper sanitation facilities and routine water treatment, can significantly reduce contamination risks [5,8]. Moreover, integrating local knowledge and participatory approaches into water management strategies enhances their effectiveness and sustainability. Policy measures should focus on both preventive and corrective actions, including regular water quality assessments, improved faecal sludge management, and public education campaigns on hygiene practices [8,5]. Strengthening the capacity of local authorities to enforce standards, combined with community engagement, can mitigate contamination risks and improve overall public health outcomes. Ultimately, protecting groundwater quality in rapidly urbanizing areas like Yaoundé requires a multifaceted approach that addresses both environmental and social determinants of water safety, ensuring access to clean water for all residents.

Study Limitations: The small sample size and cross-sectional design limit causal inference. Seasonal variations were not analyzed.

5. Conclusion

Improved well water in Nkol-Afamba meets physicochemical standards but exhibits high microbiological contamination. Latrine proximity and shallow well depth are primary risk factors. Addressing these risks requires strengthened sanitation measures, routine microbiological monitoring, and community education on water hygiene. Household-level interventions, combined with the enforcement of national and international water quality standards, can substantially reduce exposure to waterborne pathogens. Sustainable groundwater protection in peri-urban Cameroon is critical for safeguarding public health and reducing the burden of water-related diseases.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflicts of interest.

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