

Bacteriological Quality of Drinking Water in Tsévié and Its Surroundings, Togo

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Abstract To assess the microbiological quality of well and borehole water in the city of Tsévié and its surroundings and the consequences for public health. A total of 40 water samples, including 07 from wells and 33 from boreholes, were collected in August and September 2024. These samples were analyzed using standardized methods established by the *Association Française de Normalisation* (AFNOR). The analysis results revealed that well water was highly contaminated; 100% of the samples indicated fecal contamination, with 28.57% testing positive for *E. coli*. Borehole water showed lower contamination levels, with 12.12% of samples containing total coliforms and 6.06% testing positive for *E. coli*. Total germs were detected in all well water samples (100%) and in 84.84% of borehole samples. Non-compliance with European Union standards was observed in 100% of well samples, 36.36% of borehole water samples for total coliforms, and 85.71% and 12.12% of well and borehole samples, respectively, for thermotolerant coliforms. These findings highlight an alarming public health risk, particularly gastroenteritis resulting from fecal contamination of well and borehole water. At least 60% of the analyzed borehole water samples posed no gastroenteritis risk, demonstrating a higher safety level for borehole water compared to well water. Urgent measures must be adopted, including regular water quality monitoring, strengthening hygiene and sanitation measures around water supply infrastructures, and systematically treating these water sources. Such practices will ensure better water safety and, consequently, improved drinking water quality.

Keywords: Drinking water, wells, boreholes, bacteriological quality, Togo

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1. Introduction

Over the past two decades, cities in Togo have been experiencing rapid population growth, similar to other urban areas in Sub-Saharan Africa. This rapid demographic expansion, accompanied by urbanization, has been poorly managed. The occupation of urban and non-urban spaces by populations is often not followed by adequate wastewater treatment and by-product management systems. As a result, anthropogenic activities pose a significant environmental threat, particularly to water resources [1,2,3]. However, water remains a natural and essential resource for all living beings. Having access to a sufficient quantity of quality water helps maintain good health and sustains life [4,5]. Approximately 90% of diarrheal diseases are attributed to the deterioration of drinking water quality and inadequate wastewater management, disproportionately affecting vulnerable and disadvantaged populations.

Togo is among the Sub-Saharan African countries with one of the lowest water supply and sanitation coverage rates worldwide [2]. Only 41% of the Togolese population has access to proper sanitation, while 57.22% have access to drinking water [6]. The supply of urban water is managed by the Ministry in charge of water, whose objective, through its qualified services and agencies, is to provide potable water to urban populations (via *La Togolaise des Eaux - TdE*) and rural populations (through the *Village Hydraulics Division*). However, the drinking water distribution network has not kept pace with urban expansion [2]. Additionally, issues related to the lack of infrastructure and resources exacerbate the situation [7,8]. Except for the capital, Lomé, no other cities have a *Master Sanitation Plan (PDA)* [6]. The poor quality of surface and groundwater is mainly due to inadequate sanitation infrastructure or its dysfunction [9]. In response to the absence of a conventional water supply network in Togolese cities, many people, particularly in rural areas, resort to alternative water sources of questionable quality, such as wells, boreholes, ponds, cisterns, rivers, and lakes,

to meet their daily needs [2].

In Tsévié and its surroundings, despite efforts made by authorities including the state and non-governmental organizations (NGOs) drinking water supply remains insufficient [7]. This area is considered a transitional settlement for individuals aiming to live in Lomé due to the cost of living. Studies indicate that, in response to water scarcity, the population increasingly relies on well and borehole water to address availability issues [7]. While these infrastructures solve the problem of water accessibility, they do not guarantee water quality. To date, data on the quality of drinking water in the area is scarce and limited. Nevertheless, the few studies carried out have shown that the quality of these waters is not satisfactory [10].

In 2015, studies demonstrated that well and borehole water in the region were contaminated with total germs, total coliforms, and fecal coliforms. According to the World Health Organization, water intended for consumption and household use should not contain pathogenic microorganisms. No 100 mL sample of drinking water should contain sulfite-reducing anaerobic germs, coliforms, or streptococci [11]. Research by [12] found that well water analyzed in Porto Novo was contaminated with *Enterococcus*, and 31% of the samples contained *E. coli*. Similarly, studies conducted by Soncy in 2015 revealed fecal contamination indicators in 65% of well water samples and *E. coli* presence in 70% of cases. Fecal contamination indicator bacteria have been detected in well and borehole water by several researchers, including [13] in Bamako, [14] in Bangui, and [2] in Lomé. According to [15], contamination is primarily linked to the lack of sanitation infrastructure, inadequate household waste collection, the transfer of pollutants from surface soil layers, poor water-drawing conditions, and the structural quality of water supply systems. The objective of this study is to assess the bacteriological quality of drinking water in the study area and examine its potential health implications for the local population. What is the quality of the water consumed by the area's residents? What are the health risks to which they are exposed?

2. Methodology

2.1. Material

A total of 40 water samples were collected between August and September 2024. Sterile 500 mL bottles were used for sampling, along with a cooler equipped with refrigerant packs and a burner for sterilizing taps before sampling. For well water, the household's drawing bucket was used. The sampling was conducted at 7 wells and 33 boreholes, selected based on surveys and predefined criteria in the study area. Table 1 summarizes the analyzed microbial species and the culture media used. For this study, we utilized sterile 500 mL bottles and pipettes, a cooler with refrigerant elements, TSN tubes, Petri dishes, culture media, and a Bunsen burner for sterilizing pipettes using an open flame...

2.2. Sampling Criteria

After completing the prospecting campaign, 40 water sources were selected for analysis based on the following criteria:

- (1). Their accessibility;
- (2). Their high usage by the local population;
- (3). Their proximity to potential pollution sources (landfills, agricultural zones, livestock farms, fishing activities, cemeteries) [16,17];
- (4). Their non-compliance with the minimum regulatory distance of 15 meters [18].

2.3. Methods

To analyze and enumerate microbial contaminants in the collected water samples, standardized routine methods established by the *Association Française de Normalisation* (AFNOR) were implemented (Table 1). The pour plate technique was used to detect and enumerate total mesophilic anaerobic flora, total coliforms, thermotolerant coliforms, sulfite-reducing anaerobes, and fecal streptococci. The *Brilliance E. coli* culture medium was used to detect *Escherichia coli*. The selection of these microbial indicators was based on previous studies [7, 19] and WHO recommendations. Culture media were prepared in accordance with the manufacturer's technical specifications. Before sampling, an aseptic zone was created using the burner to prevent airborne contamination. The tap was then opened, and water was collected into a sterilized bottle up to the marked level. The upper part of the bottle was left filled with air to ensure microbial survival. The samples were transported to the laboratory in a cooler with refrigerant elements to maintain a low temperature and prevent microbial proliferation [10].

Table 1. Microorganisms, Culture Media, Incubation Conditions, and Characteristic Colonies [2,20]

	Target Microorganisms	Culture Medium	Incubation Conditions	Characteristic Colony
1	Total Mesophilic Aerobic Flora (NF EN ISO 4833-1)	PCA	30°C / 24-72h	Any colony
2	Total Coliforms (NF EN ISO 4832)	VRBL	30°C / 24h	Pink-Red, $\Phi > 0.5$ mm
3	Thermotolerant Coliforms (NF V08060)	VRBL	44°C / 24h	Pink-Red, $\Phi > 0.5$ mm
4	<i>Escherichia coli</i> (NF EN ISO 166492)	Brilliance <i>E. coli</i>	44°C / 24h	Blue-Green
5	Fecal Streptococci (NF EN ISO 7899-2)	Slanetz and Bartley	37°C / 24-48h	Brown
6	Sulfite-Reducing Anaerobes (NF EN ISO 15213)	TSN	44°C / 24-48h	Black, Spherical

VRBL: Violet Red Neutral Bile Lactose; PCA: Plate Count Agar; TSN: Tryptone Sulfite Neomycin

2.4. Incubation and Data Analysis

The incubation process was carried out in culture media plates at appropriate temperatures and durations, as

indicated in Table 1. Sulfite-reducing anaerobes (SRA) were identified by inoculating 1 mL of the sample into 19 mL of TSN agar (Tryptone Sulfite Neomycin), which had been prepared in test tubes. The incubation was conducted at 44°C for 48 hours after homogenization. For bacterial enumeration, 1 mL of each water sample or inoculum was pipetted and deposited into Petri dishes, following the ISO 17025 standard [21]. Subsequently, 15 to 20 mL of the corresponding culture medium was poured in a single step, then left on the bench for solidification after thorough homogenization. The Petri dishes and TSN tubes were incubated at the respective temperatures and durations specified in Table 1. The results were interpreted based on the European Union Water Quality Criteria (*Council Directive 98/83/EC*). The environmental conditions surrounding the wells and household concessions were also considered in this study.

2.5. Statistical Analysis

The microbiological analysis data were processed using Excel-based statistical analysis to determine the extreme values. These values were used in the discussion due to their significance in assessing contamination levels. Results were analyzed using Graphpad-prism 9.3.0 software. The difference between well and borehole water was calculated using the Mann Whitney test with a 95% safety coefficient and a degree of freedom at 5% risk ($P < 0.05$) [10].

2.6. Fecal Contamination Index (FCI)

The Fecal Contamination Index (FCI) was determined using the following bacterial indicators of fecal contamination: Total Coliforms (TC), *Escherichia coli* (EC), Fecal Streptococci (FS), and Sulfite-Reducing Anaerobes (SRA). The FCI was calculated using the equation: $FCI = TC + EC + FS$ [6,22]. Once the bacteriological analysis results were obtained, they were classified based on contamination levels using the following categorization table, which displays different contamination classes according to fecal indicator bacteria.

It is important to note that the calculation of the Fecal Contamination Index (FCI) is simply the sum of the class numbers of the three (03) variables. Subsequently, an assessment of drinking water quality is provided based on the contamination grading scale, as shown in the Table 2.

Table 2. Classification of Water Variable Concentrations by Category [20]

Variable Classes (VC)	1	2	3	4
EC	0	$0 < CV \leq 20$	$20 < CV \leq 20000$	$CV \geq 20000$
SF	0	$0 < CV \leq 20$	$20 < CV \leq 10000$	$CV \geq 10000$
CT	0	$0 < CV \leq 20$	$20 < CV \leq 50000$	$CV \geq 50000$

Table 3. Fecal Contamination Index (FCI) Grading Scale for Water [22]

Class	Calculated Value (FCI)	Pollution Index
1	$0 < FCI \leq 3$	No contamination
2	$3 < FCI \leq 6$	Moderate fecal contamination
3	$6 < FCI \leq 9$	High fecal contamination
4	$9 < FCI \leq 12$	Excessive fecal contamination

3. Results

3.1. Sanitary Condition of the Sampling Environment

Observations of the immediate surroundings of the wells revealed that the wells sampled for this study were traditional wells, mostly constructed by local well diggers using rudimentary equipment. These wells have an approximate diameter of 1 meter, with water depths ranging between 10 and 35 meters. Almost all the wells had an uncovered parapet (except for 5 out of 7), measuring between 0.5 and 1 meter above ground level. Around 70% of the wells were equipped with protective structures (such as small concrete slabs). Sanitary infrastructures, including septic pits and soakaways, were located within a maximum radius of 20 meters from the wells in three household compounds. However, two of the seven wells did not comply with the minimum regulatory distance of 15 meters. Notably, one well was located approximately 15 meters away from a herd of animals, with fecal matter visibly present in the area. Most of these wells were traditionally constructed in sandy areas, where the water table is relatively shallow. The boreholes sampled in this study, on the other hand, were relatively well-protected structures, consisting of wells with diameters ranging between 15 and 20 cm. They were equipped with submersible pumps and covered with small concrete slabs. Borehole water was collected in polytanks before being distributed through PVC pipes. Borehole water was intended for all household uses. According to users, well water is generally not consumed as drinking water in most households. As for household wastewater disposal, it was either directly discharged into courtyards or into the street in front of houses. Additionally, free-roaming domestic animals were observed in certain households or being raised within the compounds.

3.2. Microbiological Quality of the Analyzed Water

The microbiological analysis results revealed that all well water samples were contaminated with most of the targeted microorganisms. They exhibited high contamination levels with total mesophilic aerobic flora (TMAF) and fecal contamination bacteria. The presence

of TMAF in well water led to over 100% non-compliance with the evaluation criteria (TMAF = 100/mL). Total coliforms, thermotolerant coliforms, and *E. coli* resulted in 100%, 85.71%, and 28.57% non-compliance rates, respectively, based on regulatory standards (Figure 1). Fecal streptococci were detected in 100% of well water samples, while sulfite-reducing anaerobes (SRA) showed 0% non-compliance in well water samples. Borehole water samples were less polluted. All 33 borehole water samples complied with the standards for sulfite-reducing anaerobes (SRA) (Table 4). However, some borehole samples were non-compliant due to the presence of total coliforms (36.36%), thermotolerant coliforms (12.12%), *E. coli* (6.06%), fecal streptococci (12.12%), and TMAF (84.84%). The microbial load ratio between well and borehole water was approximately 18.6 and 42.6 times higher for TMAF and total coliforms, respectively.

The obtained bacterial counts are recorded in the Table 4, processed, and visually represented in Figure 1.

Table 4. Quality of the Analyzed Water

Analyzed Germs	Extreme Values in CFU/mL		Criteria*	Number of Satisfactory Samples	
	Wells	Boreholes		Well (N=07)	Boreholes (N=33)
Total Mesophilic Aerobic Flora	5900 19000	33 120000	100	00	05
Total Coliforms	21 280	0 59	0	00	21
Thermotolerant Coliforms	0 190	0 35	0	01	29
<i>Escherichia coli</i>	0 06	0 17	0	05	31
Fecal Streptococci	2 24	0 39	0	0	29
Sulfite-Reducing Anaerobes	0	0	0	07	33

Note: Criteria based on European Union Water Quality Standards (Council Directive 98/83/EC).

The number of germs (*E. Colis* and ASR) in borehole and well water is statically identical. On the other hand, the results for the other germs are significantly different after the Mann Whitney test.

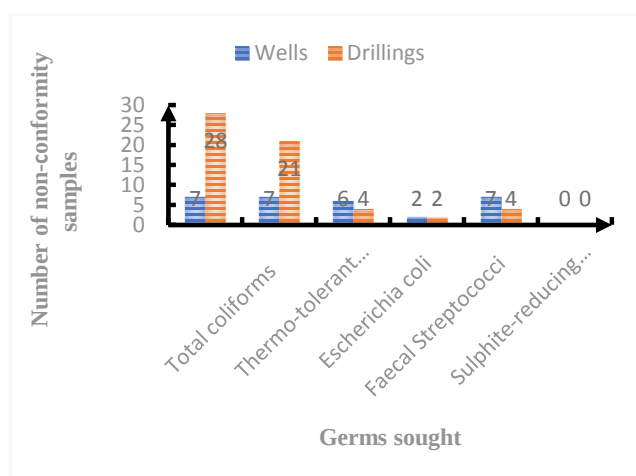


Figure 1. Non-compliance Induced by the Presence of Targeted Microorganisms

Table 5. Statistical testing of drinking water

Germs	P-values	Significant difference
TMAF	0.0128	Yes
Total Coliforms	< 0,0001	Yes
Thermotolerant Coliforms	< 0,0001	Yes
<i>Escherichia coli</i>	0,1196	No
Fecal Streptococci	< 0,0001	Yes
Sulfite-Reducing Anaerobes	No determined	-

The Fecal Contamination Index (FCI) values obtained ranged between 6 and 8, with an average of 6.57 for well water, and between 3 and 7, with an average of 3.66 for borehole water (Table 6). According to the FCI assessment, contamination levels ranged from «No contamination» to «High fecal contamination» (Class 1 to 3) for boreholes and from «Moderate fecal contamination» to «High fecal contamination» (Class 2 to 3) for wells. Most wells showed moderate contamination by fecal indicator bacteria. However, 28.57% of wells and 3.03% of boreholes were highly contaminated with fecal indicator bacteria. It is crucial to raise awareness among residents in localities such as Lilikopé and Djidjolé about the health risks associated with fecal contamination.

Table 6. Basic Statistics and Distribution of the Fecal Contamination Index (FCI) by Class

Class	Calculated Value (FCI)	Pollution Index	Wells (%)	Boreholes (%)
1	0 < FCI ≤ 3	No contamination	0	63.63%
2	3 < FCI ≤ 6	Moderate fecal contamination	71.43%	33.33%
3	6 < FCI ≤ 9	High fecal contamination	28.57%	3.03%
4	9 < FCI ≤ 12	Excessive fecal contamination	0	0

Figure 2 is a reflection of Table 6, where the x-axis represents pollution indices by class, and the y-axis represents the number of samples.

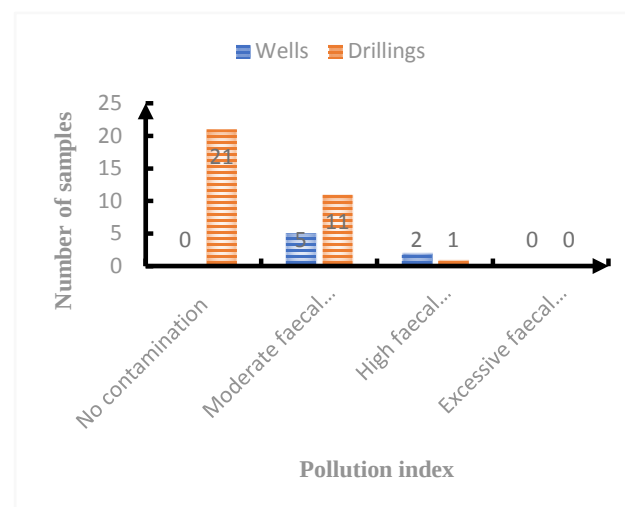


Figure 2. Water Quality Assessment Based on the Fecal Contamination Index (FCI)

4. Discussion

This study focused on evaluating the microbiological quality of well and borehole water in Tsévié and its surroundings. The results indicate that the majority of the analyzed water samples were contaminated with the targeted microorganisms. Fecal contamination was 100%, 85.71%, 28.57%, and 100% in well water and 36.36%, 12.12%, 6.06%, and 12.12% in borehole water for total coliforms, thermotolerant coliforms, *E. coli*, and fecal streptococci, respectively. Studies by [2,11,15] reached similar conclusions, highlighting excessive contamination of well water in Butembo, Niamey and Lomé with total coliforms and fecal streptococci. Comparable findings have been reported for well water in Meknes, Morocco, regarding total coliforms and fecal streptococci [23]. In Abengourou, Côte d'Ivoire, [24] detected *Escherichia coli* strains in 28% of the tested well water samples, aligning with our results. Similar strains were found by [7] in the Zio prefecture, confirming the presence of recent fecal contamination [25], particularly in the groundwater table [26]. These fecal contaminations are mainly linked to pollution sources such as the proximity of septic tanks, the presence of animal waste in courtyards, and shallow water points (10-38 m deep). This is evident from the high contamination rates observed in wells P_1 , P_3 , and borehole F_3 . The presence of these pathogens in drinking water (from both wells and boreholes) poses a serious risk of waterborne diseases for the local population. This is consistent with reported cases of gastroenteritis, as confirmed by surveys conducted in the area. Septic tanks, industrial wastewater, and solid waste disposal are among the major sources of groundwater pollution in urban and peri-urban areas. Additionally, the contamination of well water is influenced by factors such as soil permeability, water table depth, lack of or inadequate sanitation infrastructure, poor waste management, and water-drawing methods [11,21,27]. The urban expansion of Tsévié and its surroundings has exacerbated issues related to wastewater management, animal husbandry, and household waste disposal, which are key contributors to groundwater pollution. The relatively shallow depth of wells in the area further increases their vulnerability to contamination. A similar issue has been reported in Bangui, where nearly all wells are contaminated with fecal bacteria, particularly in low-altitude neighborhoods [14]. Regarding borehole water, contamination levels were significantly lower compared to well water, a finding consistent with previous studies [2,7]. This can be explained by the greater depth of boreholes (beyond 30 m), which reduces the risk of surface contamination. Fortunately, borehole water plays a major role in meeting the daily needs of local residents.

There was a significant difference ($p < 0.05$) between wells and boreholes in terms of the germs analyzed, except for *E. coli*s and ASR, after statistical testing. Drilling is carried out in the study area, where it is very difficult for households to build wells, and sometimes boreholes. This is reflected in the smaller number of wells compared with boreholes, plus the depth of the captive water table, which is sometimes linked to the elevation observed in the field. In fact, it is not only the depth that is sometimes a deterrent; several supply works have been

doomed to failure due to rocky and stony geological formations [28]. In short, the relief and geological nature of the strata offer greater access to borehole water at depths averaging over 30 meters. The accumulations of germs in the wells clearly show that well water was more contaminated than borehole water. These results justify the arguments put forward to explain them above. Several studies have shown that the shallower the water table, the more favorable it is to pollution [29].

Based on the calculated Fecal Contamination Index (FCI), well water samples ranged from moderately to highly contaminated, similar to findings by [6]. The results confirm that, from a microbiological perspective, none of the analyzed samples met the required standards for the targeted parameters. Several authors, including [10,30], and [2], have reported similar findings in Lomé and beyond, including in [31,32,33,34]. For the borehole water samples, the FCI values ranged from «no contamination» to «high contamination». Notably, 66.66% of boreholes complied with fecal contamination standards. The highest contamination levels were observed in P_1 , P_3 , and F_3 , which had shallow depths (10-38 m). Additionally, P_1 was located near animal herds and waste, factors that contributed to higher fecal contamination levels. Despite this, the borehole water remains relatively safe for consumption, with lower risks of gastroenteritis. These FCI values strongly support the non-compliance rates observed in the study. Even in households connected to the TDE (Togolaise des Eaux) water supply network, which was deemed bacteriologically safe by [3], this water is mainly used for drinking and sometimes for cooking. However, the majority of residents in the study area rely more on borehole water for most household needs. Well water, being easily accessible, is primarily used for washing dishes, doing laundry, and bathing. Contaminated water is unfit for consumption, as it can lead to waterborne diseases [5,36]. Research by [2] confirmed the presence of fecal contamination indicator bacteria in fresh juices made from fruits washed with well water in Lomé. This finding highlights the need for increased vigilance in daily water usage, particularly for activities such as washing raw food, brushing teeth, and bathing infants. It is crucial to treat water before any intended use. Various water treatment techniques exist to purify water before consumption. These methods range from basic approaches (such as boiling water and chlorination before consumption) to more advanced solutions (such as water treatment plants) [10,37].

5. Conclusion

Borehole water serves as a key source of water supply for residents in the study area, playing a crucial role in various daily activities, particularly drinking and cooking. However, its contamination with fecal-origin bacteria presents a public health risk, especially gastroenteritis. This contamination is primarily linked to inadequate sanitation, poor household hygiene practices, and unsanitary conditions around water sources. Well water was found to be heavily contaminated, with 100% of samples testing positive for total coliforms and fecal

streptococci, and 28.57% for *Escherichia coli*. Although borehole water showed lower contamination levels, it still exhibited a 36.36% non-compliance rate for total coliforms. These findings highlight fecal and hygiene-related pollution of water sources, which in turn increases the vulnerability of the population. Failure to comply with construction standards and maintain the minimum recommended distance of 15 meters between water sources and sanitation facilities exacerbates contamination risks. Due to limited land availability, some households have built sanitary facilities too close to wells and boreholes, further compromising groundwater quality. This issue stems from both a lack of awareness regarding these regulations and the absence of a structured construction plan defined by technical experts. These findings should prompt authorities to take action, organizing awareness campaigns focused on hygiene and sanitation practices, adherence to proper construction standards, and regular water quality monitoring to protect public health. Such initiatives could heighten residents' awareness of potential risks and encourage behavioral change. Future research should aim to establish a direct correlation between waterborne diseases, the sources of consumed water, and the Fecal Contamination Index (FCI).

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