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Assessment of the Microbiological Quality of Drinking Water from Some Wells and Boreholes in the City of Abeche (Chad)

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Abstract

The inadequacy of drinking water distribution by the Chadian Water Company (STE) has led to the proliferation of private wells and boreholes in the city of Abéché. This study aims to evaluate the microbiological quality of the drinking water from these wells and boreholes in the city. **Methodology:** To carry out this study, a randomized selection of forty-five (45) water points, including nine (9) wells and thirty-six (36) boreholes, was identified, and samples were collected. These samples were sent to the National Water Laboratory (LNE) to test for several microbiological parameters, namely Escherichia coli, total coliforms, fecal coliforms, fecal enterococci, and total aerobic flora. The technique used for this analysis was spread plating and membrane filtration. **Results**: The average values obtained in the well water are $0.338*10^4$ CFU/100 ml for total coliforms, $0.156*10^4$ CFU/100 ml for fecal coliforms, $0.319*10^3$ CFU/100 ml for Escherichia coli, 33.33 CFU/100 ml for fecal enterococci and $1.385*10^4$ CFU/100 ml for total aerobic flora. For borehole water, the average values obtained are $0.469*10^4$ CFU/100 ml for total coliforms, $0.134*10^4$ CFU/100 ml for fecal coliforms, $0.337*10^3$ CFU/100 ml for Escherichia coli, 16.67 CFU/100 ml for fecal enterococci and $1.47*10^4$ CFU/100 ml for total aerobic flora. **Conclusion**: According to the tolerance thresholds set by the WHO, the average values obtained significantly exceed the recommended standards for drinking water. Therefore, these waters must be treated alongside environmental sanitation measures at water points to ensure a safe drinking water supply that poses no major health risks to the population. For this fact, an appropriate health survey and the implementation of community water and sanitation projects are recommended.

Keywords

Microbiological Quality, Water, Boreholes, Wells, Abeche-Chad

1. Introduction

Water is an essential element for life on Earth. Globally, it occupies more than 70% of the Earth's surface, but less than 3% is available as freshwater and only 0.01% of freshwater is accessible for human consumption, while the remainder is limited to the Arctic and Antarctic in the form of glaciers [1]. Access to safe drinking water is a prerequisite for health, an essential human right, and a key component of effective health protection policies [2]. Yet water plays a vital role in the health of all humanity, as it accounts for more than 70% of the weight of the human body [3]. Water is essential to life, but it can also transmit disease. Waterborne infectious diseases remain a major source of morbidity and mortality worldwide, causing more than 2.2 million deaths each year, the majority of which reside in developing countries [2]. Alarming figures from WHO and UNICEF reveal that every year, 1.4 million people, many of them children, succumb to diarrheal diseases contracted due to unsafe water and lack of adequate sanitation. These problems are undeniably the cause of illness and death, particularly among children under five (5) [4]. In addition, increasing urbanization in African cities, demographic pressure related to economic development, and climate change have led to a lack of surface water usually treated and distributed [5]. Indeed, drinking water is water that can be drunk without risk to health. It is also water that respects the values imposed by law.

In Chad, drinking water is very scarce, only 1/4 of the Chadian population has drinking water at their disposal [6]. To this end, Chad, in its health policy, has established rules and recommendations to regulate the quality of water intended for human consumption, with reference to the standards required by the WHO. The Water Code has focused on the protection and quality of water service. This is implemented by decrees and laws leading to the creation of state institutions, namely: the National Water Laboratory (LNE) and the Chadian Water Company (STE) which must ensure the distribution of quality water.

Abéché is one of the many African cities where population growth and urban sprawl have evolved very rapidly over the last two decades. The city has seen more than 20,000 Sudanese and Chadian refugees arrive in response to the Darfur crisis, and it has become a center for humanitarian operations. This rapid population growth has undeniably led to a lightning-fast spatial expansion of the city, leading to social and environmental problems [7]. In these conditions, appropriate intervention strategies must be put in place to alleviate these ailments. Thus, the main purpose of this study is to evaluate the microbiological quality of drinking water from some boreholes and wells in the city of Abéché.

2. Materials and Methods

2.1. Study Framework

The study was conducted in the city of Abeche, Ouaddaï Province. It is the fourth-largest city in Chad and is located in the eastern part of the country, at a latitude of 13˚50'24" N and a longitude of 20˚49'48"E. (Figure 1)

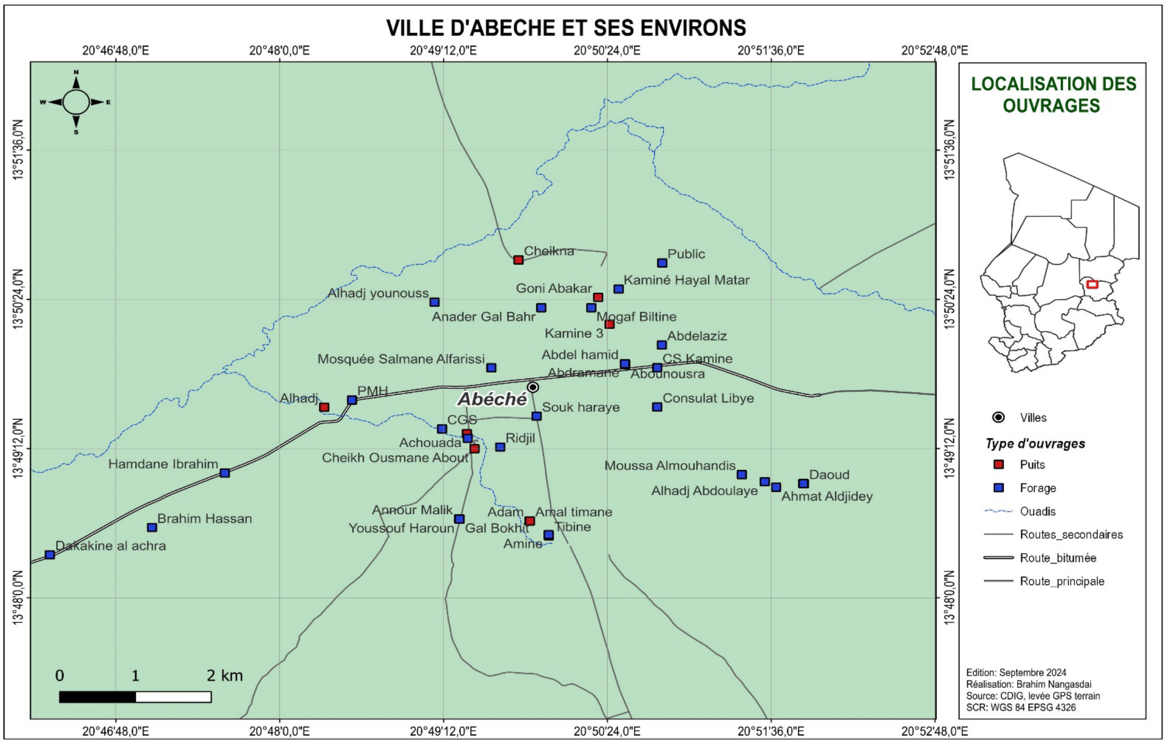

Figure 1. Mapping of sample sites investigated in the city of Abéché (LNE, 2024).

2.2. Sample Collection and Packaging

Sampling is random. The choice of works was based on the frequency of use of the site by the population, and in all districts of the city of Abéché, in order to reach all strata of the population.

The methodology used is based on the approach adopted by [8]. A total of forty-five samples were collected including nine (9) well water samples and thirty-six (36) borehole water samples. The samples were collected in sterile 500 ml glass bottles at each site. The collected samples were immediately sealed, labeled, and placed in a cooler with ice packs at a temperature of 4˚C, then transported to the National Water Laboratory in N'Djamena for microbiological analysis. Five (5) microbiological parameters were investigated and quantified in this study: total coliforms, and fecal coliforms.

2.3. Microbiological Analysis

The membrane filtration method was used to determine indicator bacteria of fecal pollution. The identification was carried out by spreading for certain samples and by filtering at least 2 ml of water through a cellulose filter membrane with uniform pore diameters of 0.45 µm.

Table 1: summarizes the techniques used, the culture media, the incubation time and temperature, and the colony colors for each microorganism.

Table 1. Search and identification method of the germs sought.

Germs wanted	Growing medium	Incubation time and temperature
Total coliforms	Gélose chromocult	24h à 36 ± 1˚C
Fecal coliforms	Gélose chromocult	24h à 44 ± 1˚C
Escherichia coli	Gélose chromocult	24h à 36 ± 1˚C
Fecal enterococci	Slanetz bartley agar	48h à 36 ± 1˚C
Total aerobic flora	PCA	24 - 48H à 36 ± 1˚C

2.4. Data Analysis

Microsoft Excel 2016 was used to perform statistical analyses of the data. The microbiological analyses were conducted in triplicate, and the results are presented as averages.

3. Results and Discussion

3.1. Average Loads of Pathogenic Germs in Well and Borehole Water

The results of the germ counting (Table 2) revealed an average load of $0.338*10^4$ and $0.469*10^4$ CFU/100 ml in total coliforms respectively of well and borehole water with extreme values between 0 and $1.6*10^4$ CFU/100ml for well water and between 0 and $1.6*10^4$ CFU/100ml for borehole water.

For fecal coliforms, the extreme values obtained are in the order of 0 to $1.04*10^4$ CFU/100 ml with an average load of $0.156*10^4$ CFU/100 ml for well water and 0 to $1.04*10^4$ CFU/100 ml with an average of $0.134*10^4$ CFU/100 ml for borehole water taking into account the tolerance threshold set by the WHO.

For Escherichia coli, the extreme values of the feedings obtained are between 0 and $1.1*10^3$ CFU/100 ml with an average load of $0.319*10^3$ CFU/100 ml for well water, and between 0 and $4.32*10^3$ CFU/100 ml with an average load of $0.337*10^3$ CFU/100 ml for borehole water.

Fecal Enterococci are present with an average load of 33.33 CFU/100 ml for well water and 16.67 CFU/100 ml for borehole water, corresponding to values ranging from 0 to 300 CFU/100 ml for well water and from 0 to 500 CFU/100 ml for borehole water.

The extreme values of total aerobic flora loads obtained are 195 and $1.9*10^4$ CFU/100 ml for well water and 192 and $1.99*10^4$ CFU/100 ml for borehole water.

The average load is 1.385*10^4 CFU/100 ml for well water and 1.47*10^4 CFU/100 ml for borehole water.

Table 2. Average loads and extreme values of the germs sought (CFU/100 ml).

Researched germs	Well water			Borehole water			WHO guidelines/ CHAD
	Min.	Max.	Ave.	Min.	Max.	Ave.	
Total coliforms	0	1.6 10^4	0.338 10^4	0	1.5 10^4	0.469 10^4	00 UFC/100 ml
Fecal coliforms	0	1.04 10^4	0.156 10^4	0	1.04 10^4	0.134 10^4	00 UFC/100 ml
Escherichia coli	0	1.1 10^3	0.319 10^3	0	4.32 10^3	0.337 10^3	00 UFC/100 ml
Fecal enterococci	0	300	33,33	0	500	16,67	00 UFC/100 ml
Total aerobic flora	195	1.9 10^4	1.385 10^4	192	1.99 10^4	1.47 10^4	-

Ave.: Average, Min.: Minimum, Max.: Maximum.

3.2. E. coli Contamination of Well and Borehole Water

Figure 2 shows the contamination levels of well and borehole water by E. coli. Overall, 62.22% of the samples are compliant and 37.78% of them are non-compliant. Borehole water had the highest percentage of compliant samples, exceeding 66.67%, whereas the majority of well water samples were non-compliant (55.56%). According to [9], the presence of E. coli in water suggests enteric pathogens and fecal pollution.

Figure 2. Drilling with the presence of livestock and wastewater.

3.3. Contamination of Wells and Boreholes Water by Total Coliforms

The results of the search for total coliforms in the well and borehole water samples from the study area are presented in Figure 3. In general:

- 80% of the samples are non-compliant;
- 20% of samples are compliant.

In the case of well water, 77.78% of the samples are non-compliant. For borehole water, 80.56% of the samples do not meet WHO standards.

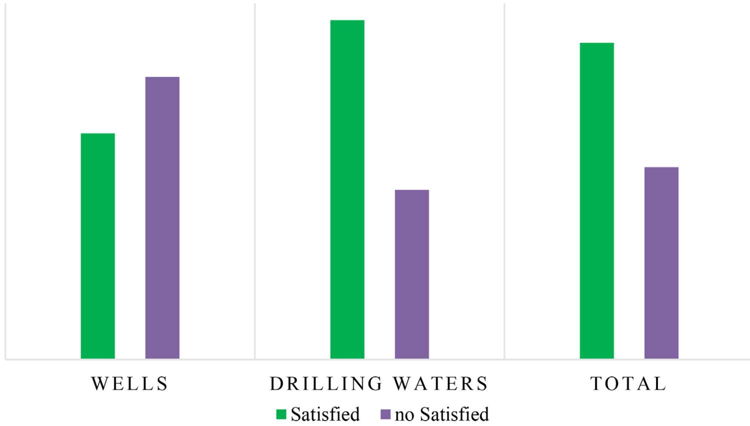

Figure 3. Compliance rates of well and borehole water with respect to E. coli.

3.4. Contamination of Well and Borehole Water by Fecal Coliforms

The enumeration of fecal coliforms in well and borehole water is illustrated in **Figure 4**. Among all the samples collected, only 20% are compliant with WHO standards. Specifically, 22.22% of well water samples and 19.44% of borehole water samples meet the standard.

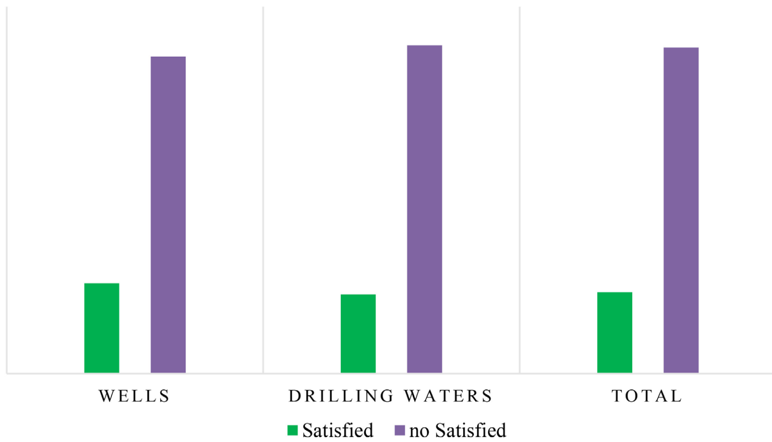

Figure 4. Compliance rate of well and borehole water relative to total coliforms.

3.5. Contamination of Well and Borehole Water by Fecal Enterococci

Figure 5 shows the contamination levels of well and borehole water by fecal enterococci. In well water, 88.89% of the samples are compliant with 11.11% of non-compliant samples. For borehole water, only 5.56% of the samples were non-compliant with WHO standards.

3.6. Contamination of Well and Borehole Water by Total Aerobic Flora

The results of the search for total aerobic flora in the well and borehole water samples from the study area indicated that all samples were non-compliant with the standard. (**Figure 6**)

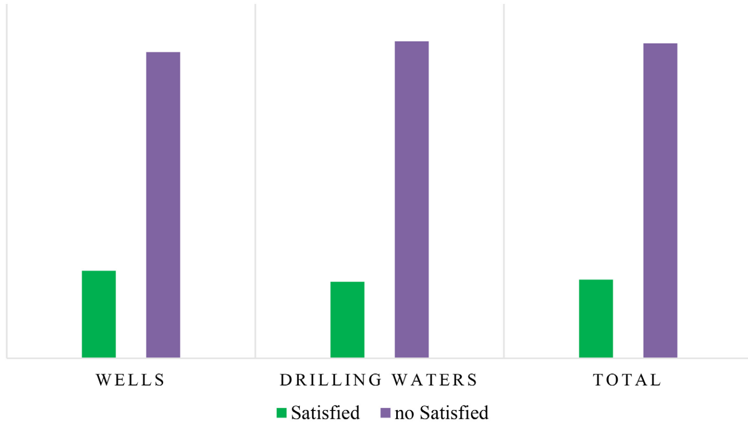

Figure 5. Compliance rate of well and borehole water with fecal coliforms.

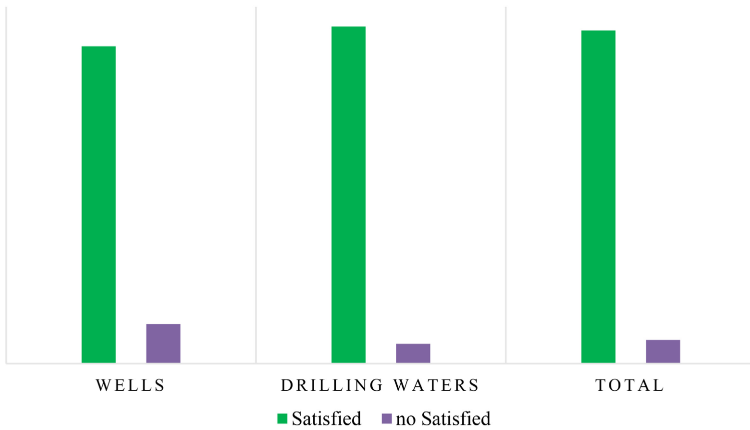

Figure 6. Compliance rate of well and borehole water against fecal Enterococci.

3.7. Discussion

Drinking water is water that can be drunk without risk to health; standards have been established to define specific drinking water, including maximum concentrations that must not be exceeded for a number of harmful substances present in water. According to these standards, drinking water must be free from pathogens (bacteria, viruses) and parasitic organisms, because of the health risks associated with these micro-organisms [10]. Indeed, microbiological analysis of water enables us to assess the risk of pathogenic micro-organisms, which can be found in water intended for domestic use, and which could consequently cause illness, and also to monitor the effectiveness of disinfection treatments [11].

Microbiological analyses of well and borehole water samples collected in the city of Abéché revealed that the averages of total coliforms, fecal coliforms, Escherichia coli, fecal Enterococci, and total aerobic flora exceeded the Chadian national standard/WHO guidelines, which state that no detectable micro-organisms per 100 ml of volume for drinking water. Consuming this water poses a public health risk. The results are similar to those obtained by [12] [13] in their studies assessing the quality of domestic well water in certain communes of Abidjan (Côte d'Ivoire). Their results showed a high bacterial load, with the presence of clostridia, total coliforms and intestinal enterococci in water from the four communes studied. The presence of E. coli in the water indicates not only recent fecal contamination, but also the possible presence of pathogenic bacteria, viruses, and protozoa [14].

The analysis of the results showed that a large majority, specifically 80% of the samples collected, are contaminated with total and fecal coliforms. These findings are similar to those from a study conducted by [15] on drinking water from wells and boreholes in the Nawa and San Pedro regions of Côte d'Ivoire, where 86% of the samples contained these microorganisms. According to [10], the presence of coliforms in drinking water is sufficient reason to assume the existence of a potential health hazard (possible presence of pathogens).

The high contamination, in total and fecal coliforms of well and borehole water, obtained in this study may be partly due to non-compliance with the distance requirements between water points (wells or boreholes) and latrines, surface water infiltration, and a lack of maintenance of these water sources. In most cases, the distance between water points and latrines is not sufficiently large (≥15 m), allowing effluents from these facilities to migrate towards the groundwater and cause contamination. The WHO recommends that boreholes be installed at least 15 meters away from all sources of pollution.

Fecal coliforms originate from animal or human sources, and their presence in water indicates recent contamination by fecal matter [16]. Abuzerr *et al.* showed a strong correlation (r = 0.7) between fecal coliforms and waterborne pathogens of the giardia type, a digestive parasitosis causing profuse diarrhoea, sometimes leading to dysenteric syndrome accompanied by abdominal pain.

It is important to note that in the study area, most wells are constructed without coping or cover, allowing rainwater and runoff, which carry various waste materials, to easily enter them. The use of an uncovered scoop for water collection further promotes the contamination of well water. According to [17], well water in the Damas neighborhood of Yaoundé (Cameroon) is polluted, particularly due to the proximity of wells to latrines, septic tanks, and open sewer systems [18], studied the factors contributing to the degradation of domestic well water in the commune of Pobè, Benin, confirmed that all wells were contaminated with fecal indicator germs. The results of this study are lower than those [19] and [20], who demonstrated the presence of total and fecal coliforms in well water samples at high concentrations ranging from 500 to 29,105 CFU/100ml. For total coliforms, concentrations ranged from 500 to 29.1, and for fecal coliforms, from 30 to 448 × 10^3 CFU/100 ml.

The presence of E. coli in well and borehole water may also be due to contamination from human or animal feces or wastewater. This contamination can occur by infiltration [21]. According to [22], microorganisms from surface runoff can penetrate the soil and enhance the activity of their vital functions, facilitating their migration toward groundwater. The presence of fecal coliforms, such as E. coli, in water has health implications for consumers. This strain is pathogenic for humans and can even cause intestinal disorders resembling gastroenteritis, cholera, and dysentery. Our observations in the field lead us to conclude that the presence of E. coli could be due to the presence of animals around watering holes. According to [23], E. coli bacteria are responsible for diarrhea. [24] clearly demonstrated that the detection of enterococci was strongly associated with the presence of E. coli in groundwater.

It is therefore imperative to monitor water quality to prevent potential risks. Consumer and stakeholder awareness is crucial to establishing sanitation and hygiene practices at source [25] [26] recommended that water contaminated with E. coli bacteria should not be consumed unless it has been boiled for at least one minute. In addition, people should not wash or prepare food, brush their teeth, or bathe babies with this water. To compensate for the inadequacy of the water supply network and reduce the risk of water-borne diseases, chlorination adapted to the composition of the borehole water will also be necessary to make it potable, using sodium hypochlorite, also known as bleach.

4. Conclusions

The present study focused on the assessment of microbiological quality of well and borehole water in the city of Abeche. The majority of samples contained total and fecal coliforms, and all samples had total aerobic flora. Thus, the study indicates that, overall, the well and borehole water in Abéché is of poor quality. The potential risk to consumers requires rapid intervention to mitigate the potential impact of waterborne diseases on community health.

This water must be treated and the water point environments improved for non-impactful consumption. We must redouble our efforts and raise awareness among populations to continue to offer them good-quality water. In addition, the incidence of waterborne diseases among the population of Abéché has not received sufficient attention in previous studies. Therefore, there is an urgent need for a quantitative microbial risk assessment to estimate the burden of disease attributable to the consumption of poor-quality water in order to protect the population.

Authors' Contributions

This work was carried out in collaboration among all authors. Authors Mablahi Amina Kanika and Soudy Imar Djibrine initiated the research project. Authors Alhadj Markhous Nazal and Mablahi Amina Kanika participated in the analyses and wrote the initial version of the article, processed the data, and participated in writing the article. Authors Oumalkher Youssouf Adam and Yacoub Alamine read the article and made corrections. Author Akoïna Moursal participated in sampling and analyses. Author Soudy Imar Djibrine supervised this research project. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare that there is no conflict of interest related to this article.

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