Microbiology Research Journal International

Volume 34, Issue 10, Page 68-76, 2024; Article no.MRJI.124276
ISSN: 2456-7043, NLM ID: 101726596
(Past name: British Microbiology Research Journal, Past ISSN: 2231-0886, NLM ID: 101608140)

Assessment of the Bacteriological Quality of Drilling Water in the 8th District of the City of N'Djamena (Chad)

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Authors' contributions

This work was carried out in collaboration among all authors. Authors HMA and OM initiated the research project. Author AMN participated in the analyses and wrote the initial version of the article, processed the data and participated in writing the article. Authors YMA and MAK read the article and made corrections. Author OM participated in sampling and analyses. Authors HMA and AMN supervised this research project. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/mrji/2024/v34i101492

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/124276

Original Research Article

Received: 24/07/2024
Accepted: 27/09/2024
Published: 08/10/2024

ABSTRACT

Study is to evaluate the bacteriological quality of borehole water consumed by residents of the 8th district of the city of N'Djamena. Twenty (20) samples were taken and sent to the National Water Laboratory for the research of microbiological parameters. Four microbiological parameters were

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Cite as: *Allamine, Hisseine Mahamat, Alhadj Markhous Nazal, Yacoub Mahamat Allamine, Mablahi Amina Kanika, and Oumar Mahamat. 2024. "Assessment of the Bacteriological Quality of Drilling Water in the 8th District of the City of N'Djamena (Chad)". Microbiology Research Journal International 34 (10):68-76. https://doi.org/10.9734/mrji/2024/v34i101492.*

evaluated: Total coliforms, *Escherichia coli*, Fecal enterococcus and *Salmonella spp*. The technique used for this analysis is spreading and membrane filtration. The average values obtained in the samples are 0.338 10^4 CFU/100 ml for total coliforms, 0.319 10^3 CFU/100 ml for *Escherichia coli*, 33.33 CFU/100 ml for fecal Enterococcus and 1.385 10^4 CFU/100 ml *Salmonella spp* . The results of these analyses, considering the tolerance threshold set by the drinking water standards in Chad, showed that these averages largely exceed the recommended standards for drinking water. These waters must be treated and the environments of water points improved for consumption without impact.

Keywords: Drinking water; bacteriological quality of water; drilling; N'Djamena; Chad.

1. INTRODUCTION

Water is essential for the life of living beings. An essential foundation of life, it remains a crucial resource for the survival of all beings on earth [1]. It contributes to the proper functioning and balance of the physiology of humans, animals and plants. Having water available in sufficient quantity and quality contributes to the proper functioning and balance of living beings [2]. Water resources come from surface water and renewable and non-renewable groundwater [3]. It is a natural and common resource, but rare in terms of quality [4]. It is essential for life, but it can and still transmits diseases in countries on all continents, from the poorest to the richest [5]. Water is therefore a fragile and precious resource threatened by various sources of pollution. The protection of these natural resources against all forms of pollution is essential to maintain their good quality [6]. 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 issues are undeniably the source of illness and death, especially among children under 5 years of age [7].

Chad, in its health policy, has established rules and recommendations to regulate the quality of water intended for human consumption and this in reference to the standards required by the WHO. The water code has highlighted the protection and quality service of water. This is implemented by decrees and laws leading to the creation of state institutions namely: the National Water Laboratory (LNE), the Chadian Water Company (STE) and the National Water Fund (FNE) which should ensure the distribution of quality water. The city of N'Djamena is equipped with facilities producing drinking water but these only serve part of the city's neighborhoods and this represents a low coverage of drinking water supply. However, being able to supply drinking water is a basic need and, therefore, would be a fundamental right.

The population of the commune of the 8th district of the city of N'Djamena is forced to indulge in the consumption of borehole water [8]. But these boreholes are drilled more or less uncontrolled, without respecting the positioning concerning the latrines, and at shallow depths. In addition, the commune of the 8th district sometimes experiences the phenomenon of flooding, the consequence of which is the infiltration of water which contaminates the water table. The consumption of borehole water in this commune can present a risk to the health of the population. Microbiological contamination of fecal origin is a problem that has a major impact on water quality worldwide [9]. Monitoring and control of the quality of drinking water remain a sine qua non-condition for improving the living conditions of populations. This aspect therefore leads us to reflect on the theme of the sanitary quality of drinking water in this municipality. Hence the general objective of this study is to determine the bacteriological characteristics of borehole water consumed in the municipality of the 8th district of the city of N'Djamena.

2. MATERIALS AND METHODS

2.1 Study Framework

The study was conducted in the commune of the 8th district of the city of N'Djamena (Chad). Microbiological analyses were carried out at the National Water Laboratory.

The commune of the 8th district was created by order No. 005/PR/2011 and is subdivided into six (6) districts: Diguel, Ndjari, Angabo, Zaffaye East; Zafaye West and Machaga . It is located to the east of the city of N'Djamena and is bordered to the north and east by the commune of the 10th district, to the west by the commune of the 2nd,

Table 1. Method of Research and Identification of Germs Research

Germs Wanted	Culture Medium	Incubation Time and Temperature
Total Coliforms	Chromocult agar	24h at 36±1°C
Escherichia Coli	Chromocult agar	24h at 36±1°C
Fecal Enterococci	Slanetz Bartley Agar	48h at 36±1°C
Salmonella spp	PCA and Lactose Agar with TTC and Tergitol 7	72h at 37±1°C and 42±1°C

Results are expressed as colony forming units per 100 ml of sample

4th and 5th districts and finally to the south by the 7th district According to the general census of the population and housing, the commune of the 8th district had 184,641 inhabitants with a growth rate of 3.5% [10]. The commune of the 8th district enjoys a dry tropical Sahelian climate. The average annual rainfall ranges from 500 to 700 mm and the average annual temperature is 28°C.

2.2 Sample Collection and Packaging

Twenty (20) borehole water samples were collected aseptically in sterile 500 ml glass bottles. Once the samples were taken, the bottles were immediately recapped, labeled and placed in a cooler equipped with ice accumulators at a temperature of 4 ° C and transported to the National Water Laboratory in N'Djamena for microbiological analyses. Four (4) microbiological parameters were sought and counted in this study: Total coliforms, *Escherichia coli*, Fecal enterococci and *Salmonella spp*. All sampling points were recorded using a Garming GPS. GPSmap 62 to bring out a geolocation map.

2.3 Microbiological Analysis

The membrane filtration method was used for the determination of indicator bacteria of fecal pollution [11]. Identification was made spread for some samples and by filtration of at least 2 ml of water on a cellulosic filter membrane having pores of uniform diameter equal to 0.45 µm. Table 1 summarizes the techniques used, culture media, incubation time and temperature according to each germ.

2.4 Data Analysis

Microsoft Excel 2016 software was used to perform statistical analyses of the data. Microbiological analyses were performed in triplicate. Results are presented as means.

3. RESULTS AND DISCUSSION

3.1 Average Pathogen Loads in Drilling Water

The results of the germ count (Table 2) showed an average load of 0.55 CFU/100 ml in total coliforms with extreme values between 0 and 100 CFU/100 ml. As for *Escherichia coli*, the extreme values of the loads obtained are also between 0 and 100 CFU/100 ml with an average load of 44.3 CFU/100 ml. Fecal Enterococci are present with an average load of 2.4 CFU/100 ml corresponding to values that oscillate between 0 to 48 CFU/100 ml. Extreme values of loads in *Samonella spp* obtained are 0 and 50 CFU/100 ml with an average load of 10 UFC/100 ml.

3.2 Contamination of Borehole Water by Total Coliforms

The results of the search for total coliforms in the samples of drilling water from the study area are given in Fig. 1. In general:

- 60% of samples do not comply with the Chad and WHO standards;
- 40% of the samples are compliant;

These results could be explained by the presence of waste water and animals but also the lack of hygiene around the water point.

3.3 Contamination of Borehole Water by *E. coli*

Fig. 2 shows the level of contamination of borehole water by *E. coli*. The majority of the borehole water samples analyzed (60%) do not comply with the Chadian national standard/WHO guidelines which was established "no detectable microorganisms per 100 ml volume". Only 40% of the samples are compliant.

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

Germs Wanted	Drilling Water			Chad / WHO Standards
	Min.	Max.	Avg.	
Total coliforms	0	100	0.55	00 CFU/ 100 ml
Escherichia coli	0	100	44.3	00 CFU/ 100 ml
Fecal enterococci	0	48	2.4	00 CFU/ 100 ml
Salmonella spp	0	50	10	0/5 ml

Avg : Average *Min: Minimum* *Max. : Maximum*

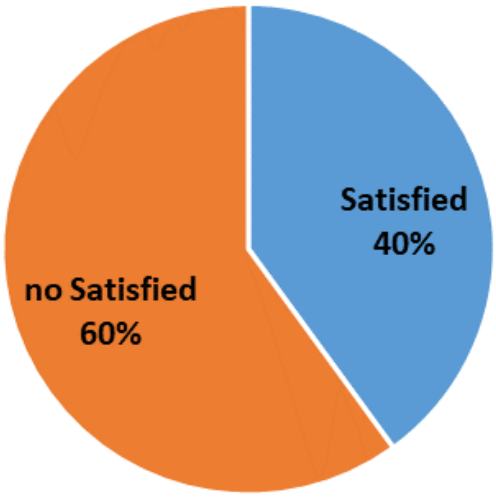

Fig. 1. Conformity rate of borehole water in relation to total coliforms

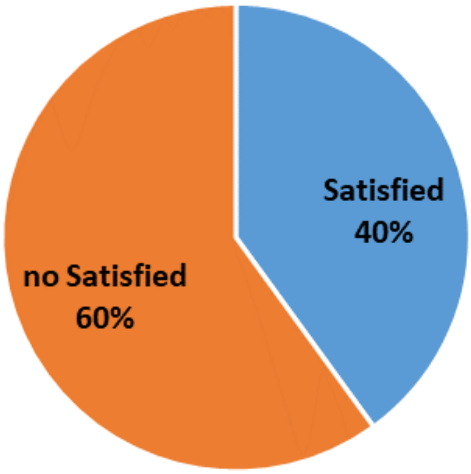

Fig. 2. Compliance rate of borehole water with respect to *E. coli*

The presence of *Escherichia coli* in borehole water indicates the possible presence of pathogenic microorganisms. It is the main bacterium of the fecal coliform group. The latter are indicators of contamination of fecal origin because they always appear in large quantities in animal and human excrement. This strain is pathogenic for humans and can even cause intestinal disorders resembling gastroenteritis, cholera and dysentery. and our observations in the field lead us to claim that the presence of *E. coli* could be due to the wandering of animals around water points as shown (Fig. 3).

Fig. 3. Drilling with the presence of livestock and wastewater

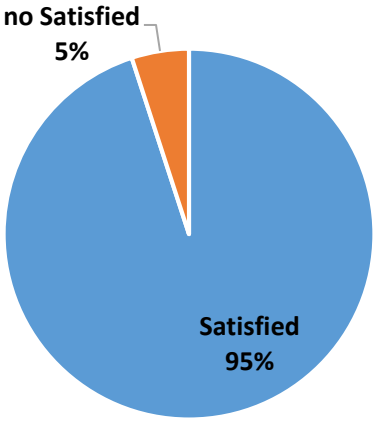

Fig. 4. Compliance rate of borehole water with respect to fecal Enterococci

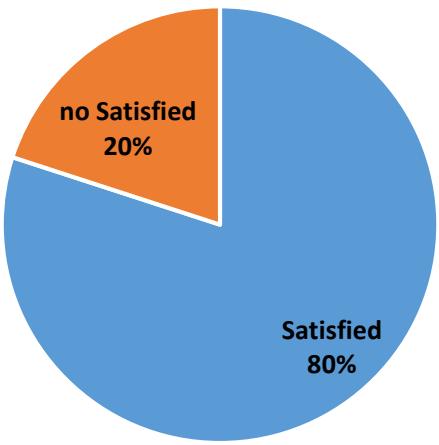

Fig. 5. Compliance rate of borehole water with respect to salmonella

3.4 Contamination of Borehole Water by Faecal Enterococci

Fig. 4 shows the levels of contamination of well and borehole water by faecal Enterococci. 95% of water samples are compliant for 5% of samples non-compliant compared to the Chad and WHO standard.

3.5 Contamination of Well and Borehole Water by *Salmonella spp.*

The enumeration of salmonella in borehole water is illustrated in Fig. 5. of all the samples taken, 80% are compliant with the Chad standard. 20% of the borehole water samples analyzed are non-compliant with the standard.

3.6 Discussion

Bacteriological analyses of samples of borehole water taken in the commune of the 8th district of the city of N'Djamena revealed the presence of the germs sought with averages higher than the standards recommended in Chad for drinking water. This presence shows that the water is subject to microbiological pollution of human origin [12]. The consumption of this water constitutes a public health risk. These results are in agreement with those obtained by [13-14] during their studies on the evaluation of the quality of well water for domestic use 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 the water of the four communes studied. The results of this study are lower than those of [15-16] which highlighted the presence of total and fecal coliforms in well water samples at high concentrations ranging from 500 to 29.10 ^{5} CFU/100mL for total coliforms and 30 to 448.10 ^{3} CFU/100 ml for fecal coliforms.

Analysis of the results showed that most of the samples taken were polluted by the presence of total coliforms and *Escherichia coli*. These results are similar to the results from the study carried out on drinking water from wells and boreholes in the Nawa and San Pedro regions of Ivory Coast where the author found that 86% of the samples contained these germs [17]. Total coliforms are of animal and human origin, their presence in water indicates recent contamination by fecal matter [18]. Thermotolerant coliforms indicates the almost certain existence of fecal contamination of water [19, 20, 21, 22]. The presence of E. coli **provides** indisputable proof of recent fecal pollution [23].

The presence of these contamination germs in drilling water may be due to contamination by human or animal feces or wastewater. This contamination can occur by infiltration [24]. From surface runoff water, microorganisms penetrate the soil and increase the activity of their vital functions, allowing good migration towards groundwater [25]. The presence of fecal coliforms such as *E. coli* in water, to consequences on the health of consumers. *E. coli bacteria* are responsible for diarrhea [26,27] have clearly demonstrated that the detection of enterococci was strongly linked to the presence of *E. coli* in groundwater.

The presence of these contamination germs may also be due to failure to respect the distance separating the borehole from latrines or cesspools. Indeed, when this distance is not sufficiently large (≥15 m) according to the WHO recommendation, the effluents from these infrastructures can migrate towards the tablecloth and to provoke its pollution [28].

Other studies have shown that the minimum distance of 15 meters also does not guarantee non-contamination of wells by latrines and have proposed an ideal distance varying from 30 to 50 meters [29,30,31]. Other studies have shown that proximity to latrines was not always associated with poorer water quality [32]. The presence of total coliforms in drinking water does not generally indicate fecal contamination or a health risk, but rather a degradation of the bacterial quality of the water [28].

This degradation can be attributed, among other things, to an infiltration of surface water or to the progressive development of a layer of bacteria on the walls called "biofilm" [33]. In view of our observations in the field, these results could be explained by the presence of waste water, lack of hygiene around the water point and the presence of domestic animals.

The presence of Enterococci in the water analyzed may be due on the one hand to the infiltration of wastewater that is loaded with microorganisms and on the other hand to poor assembly of the drilling equipment. Indeed, when the waterproofing device of the drilling is not well ensured, there may be diffusion of external water into the water table promoting its pollution. The presence of this Enterococcus in the analyzed

sample can also be explained by the fact that it is very resistant to more difficult conditions and persists longer in the water than *E. coli* [34].

It is imperative to monitor water quality to prevent potential risks. Consumer and stakeholder awareness is crucial to establish sanitation and hygiene practices at the source level [35,36] 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 a baby with this water. In order to compensate for the inadequacy of the water supply network and reduce the risk of waterborne diseases, chlorination adapted to the composition of borehole water will also be necessary to make it drinkable by using sodium hypochlorite, also known as bleach.

4. CONCLUSION

This study focused on the assessment of the bacteriological quality of borehole water consumed by residents of the 8th district of the city of N'Djamena. Most samples contained total coliforms and *Escherichia coli*. Contamination of this water by bacteria of fecal origin constitutes a major risk of gastroenteritis for consumers. The causes are mainly the lack of sanitation and bad habits in hygiene management. This water must be treated and the environments of water points improved for consumption without impact. We must redouble our efforts and raise awareness among populations to continue to offer them good quality water and reduce the incidence of water-related diseases.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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