Original Research Article

Assessment of the bacteriological quality of drilling water in the 8th district of the city of N'Djamena (Chad)

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 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 remains 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 8^{th} 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 , 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 (**Figure 1).**

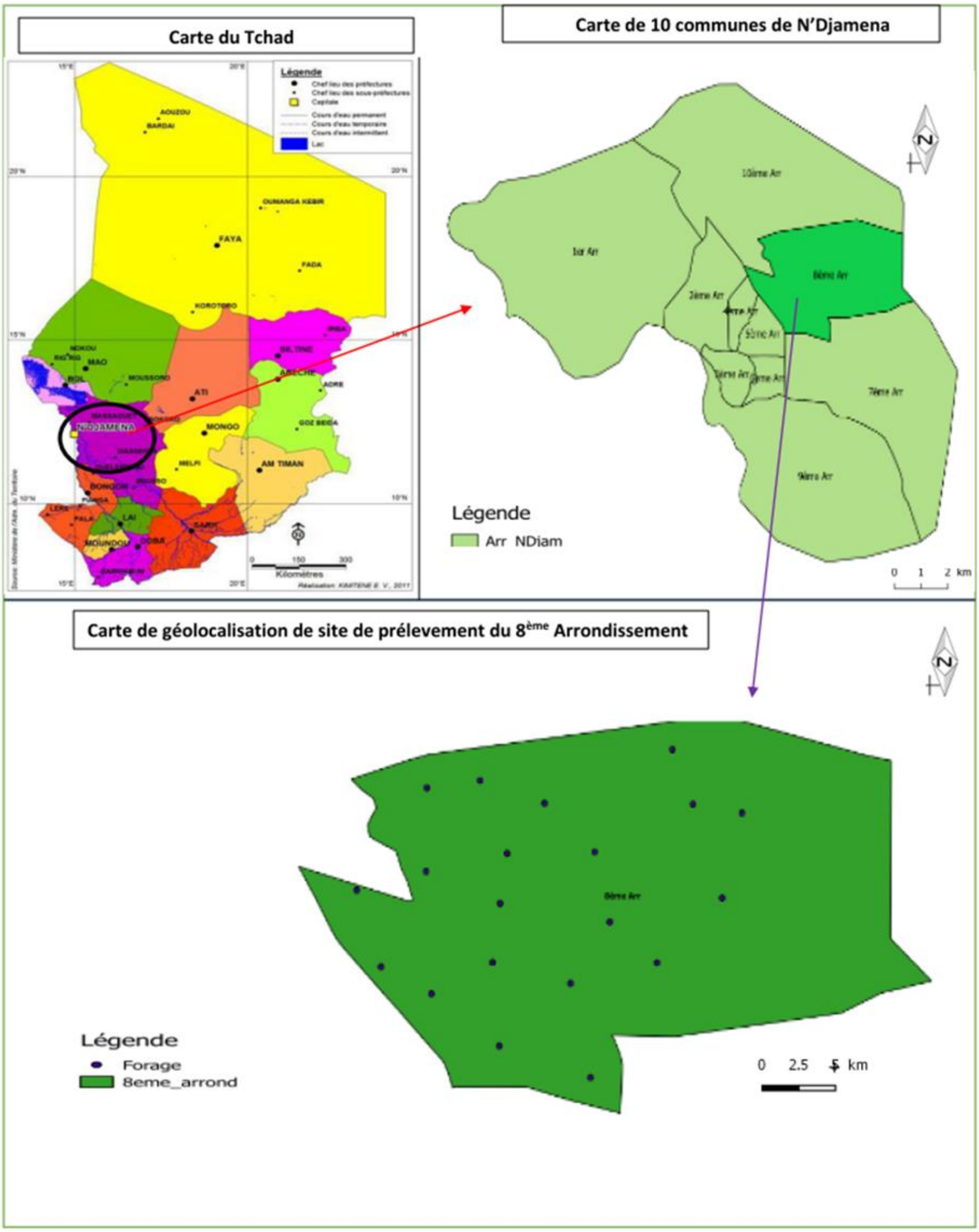

Figure 1: Geolocation of the study area

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.

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.

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.

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

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 Figure 2. In general:

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

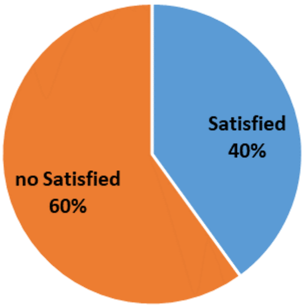

Figure 2 : Conformity rate of borehole water in relation to total coliforms

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*

Figure 3 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.

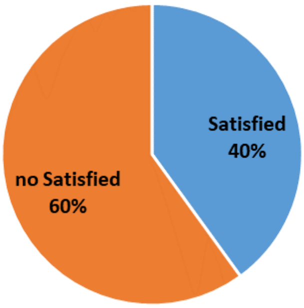

Figure 3 : Compliance rate of borehole water with respect to *E. coli*

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 (**Figure 4**) .

Figure 4 : Drilling with the presence of livestock and wastewater

3.4 Contamination of borehole water by faecal Enterococci

Figure 5 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.

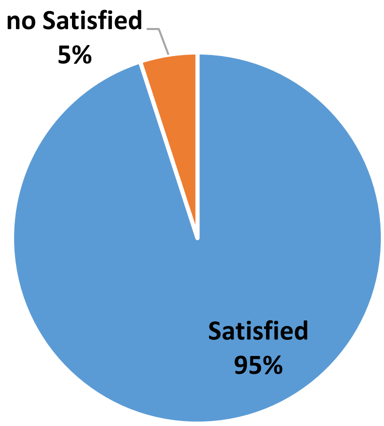

Figure 5 : Compliance rate of borehole water with respect to fecal Enterococci

3.5 Contamination of well and borehole water by *Salmonella spp.*

The enumeration of salmonella in borehole water is illustrated in Figure 6. 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.

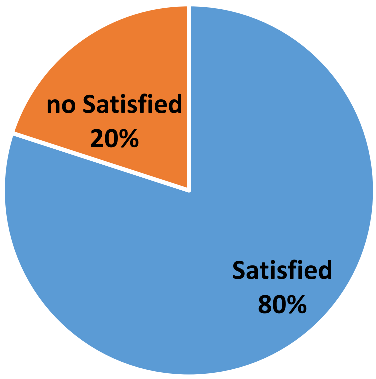

Figure 6 : Compliance rate of borehole water with respect to salmonella

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 the majority 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. The majority of 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 .

References

1. Hounsou , M., Agbossou , E., Ahamide , B., & Akponikpe , I. 2010. Bacteriological quality of water in the Ouémé basin: Case of total and fecal coliforms in the Okpara , Djougou and Savalou reservoirs in Benin. International Journal of Biological and Chemical Sciences 4(2): 377-390.
2. Saïnou, J. E., Béhanzin, P., Mariano, S., & Johnson, F. I. 2019. Study of the physico-chemical and bacteriological quality of drinking water in the municipality of Toffo in Benin : Case of Sèhouè. Journal of Applied Science and Environmental Studies 2(3): 2 3.
3. Harrat , N., & Achour, S. 2010. Physicochemical pollution of the waters of the El Tarf region dam . Impact on chlorination. LARHYSS Journal ISSN 8: 47-54.
4. Chouti , WK, & Hounkpèvi , E. 2018. Chemical and bacteriological qualities of the waters of the Mono River, southwest Benin. Africa SCIENCE 14(5): 23 32.
5. WHO. 2017. Guidelines for Drinking Water Quality. World Health Organization, 4th edition, Geneva - Switzerland
6. Adjagodo , A., Ayi-fanou , L., Kelome , NC, Tchibozo , MAD, Dovonou , F., & Amoussou , ARK 2018. Water quality of the Ouémé River during the high water period of 2016 in the Commune of Aguégués in southern Benin. Afrique SCIENCE 14(2): 100 111.
7. The WHO Regional Director for Africa reports. 2022. Health in Africa: Africa.
8. Oumar M. Control of the bacteriological quality of drinking water in the 8th district of the city of N'Djamena. Final thesis of training as a design engineer in hydraulics and water management. University of Maroua - Cameroon. 2018.
9. Hounsounou , EO, Agassounon Djikpo Tchibozo , M., Ayi-Fanou , L., & Agbossou , E. 2017. Public network water chain in some precarious neighborhoods of the sixth district of Cotonou-Benin. VertigO - the electronic journal in environmental sciences 17(3): 1-18.

10. INSEED. Overall results. Second general census of population and housing (RGPH2). Republic of Chad. 2009, 88p.
11. Denyigba , 1997. Practical workbook. Water microbiology. Sanitary engineering. Volume 1. EIER, 1997. ISBN/ISSN/EAN: ER 3310
12. Ahoussi KE, Koffi YB, Kouassi AM, Soro G, Soro N, Biemi J. 2012. Study of the chemical and microbiological characteristics of water resources in the N'zi watershed : case of the commune of N'zianouan (Southern Ivory Coast). International Journal of Biological and Chemical Sciences, 6(4): 1854-1873. DOI: http://dx.doi.org/10.4314/ijbcs.v6i4.40
13. Ouattara A, Meite A, Dally T, Ouattara H, Kati-Coulibaly S. Study of the quality of drinking water in the locality of N' Zianouan s/p of Tiassalé and the precarious neighborhoods of three communes of the District of Abidjan (Koumassi, Treichville, Attécoubé). Journal of Applied Biosciences 102: 9708 – 9715
14. Yapo OB, Mambo V, Seka A, Ohou MJA, Konan F, Gouzile V, Tidou AS, Kouame KV, Houenou P, 2010. Assessment of the quality of well water for domestic use in disadvantaged neighborhoods of four communes of Abidjan (Côte d'Ivoire): Koumassi, Marcory, Port-Bouet and Treichville Int. J. Biol . Chem . Sci . 4(2): 289- 307. http://dx.doi.org/10.4314/jab.v102i1.5
15. Coumaré K., Diallo T., Siby L., Haidara A., Traoré M., Coulibaly M., Sangaré D., Traoré IT, Tangara D., Coulibaly SM and Koumaré BY The bacteriological quality of drinking water (boreholes and wells) in three circles of the Koulikoro region, Mali. Malian Journal of Infectiology and Microbiology, (2018). https://doi.org/10.53597/remim.v0i1.983
16. Djuikom E, Temgoua E, Jugnia L, Nola M, Baane M. 2009. Bacteriological pollution of water wells used by populations in the Urban Community of Douala - Cameroon. Int. J. Biol . Chem . Sci ., 3(5): 967-978. DOI: https://doi.org/doi:10.4314/ijbcs.v3i5.51076
17. N'guetta JP 2017. Evaluation of the effectiveness of two techniques for "home water treatment" of drinking water from wells and boreholes in the Nawa and San Pedro regions. State thesis of Doctor of Pharmacy. Félix Houphouët-Boigny University - Ivory Coast
18. Chevalier P., 2003: Total coliforms. Fact sheets on drinking water and human health. Scientific group on water, National Institute of Public Health of Quebec, P 4.
19. Richard C., 1996: Water, bacteria, humans and animals, Ed. Scientifiques et Médicales, Elservier , Paris, P 115.
20. Figarella J., Leyral G., 2002: Water analysis : Regulatory and technical aspects. Ed. Scérén CRDP d'Aquitaine, Paris, P 360.
21. Rodier J., Bernard L., Nicole M., Régis B. Water analysis, 9th edition, Ed. Dunod , 2009, 1579p.
22. El Haissoufi H, Berrada S, Merzouki M, Aabouch M, Bennani L, Benlemlih M, Idir M, Zanibou A, Bennis Y, OualiLalami A. 2011. Pollution of well water in some neighborhoods of the city of Fez. Morocco. Rev. Microbiol . Ind . San et Environn ., 5 (1): 37-68. Available at https://www.citefactor.org/article/index/72038/pdf/pollution-des-eaux-de-puitsde-certains-quartiers-de-la-ville-de-fesmaroc
23. WHO., 2004 - Guidelines for drinking-water quality. 3rd ed., Vol 1. Guidelines, Ed. World Health Organization, Geneva, 110 p.
24. Alhabo A A. Qualitative study of water from manual drilling carried out in the peri-urban area of the city of N'Djamena/Chad. Master's thesis in environment, International

Institute of Water and Environmental Engineering, 2IE, 2015, Ouagadougou 01 - Burkina Faso.
25. Gounot A.M. Microbial ecology of groundwater. In : Gibert J. & Stanford J. (Editors), Groundwater Ecology. Academic Press, 1994, San Diego, 189-219.
26. Bitton G. Wastewater microbiology, Second Ed. Wiley-liss, 1999, New York. 578 p.
27. Charrière G., Mossel D.A.A., Beaudeau P. et Leclerc. H. Assessment of the marker value of various components of the coli-aerogenes group of Enterobacteriaceae and of a selection of Enterococcus spp. for the official monitoring of drinking water supplies. Journal of Applied Bacteriology, 1994, 76: 336-344 p.
28. National Collaborating Centre for Environmental Health (revised August 2013) "Microbial Indicators in Drinking Water Assessment: Interpreting Laboratory Results and Understanding Their Public Health Significance", 13p
29. Seki TO, Yapo WT Kpaibé SAP, Meless DFR and Amin N C. Physicochemical and microbiological characterization of drinking well water from the city of Aboisso (South-East of Côte d'Ivoire). Int. J. Biol . Chem . Sci . 18(1): 311-325, 2024. DOI: https://dx.doi.org/10.4314/ijbcs.v18i1.26
30. Chaúque BJM, Chicumbe CM, Cossa VC, Rott MB. 2021. Spatial arrangement of well and latrine and their influence on water quality in clayey soil – a study in lowincome peri-urban neighborhoods in Lichinga, Mozambique. Journal of Water, Sanitation and Hygiene for Development, 11: 241-254. DOI: https://doi.org/doi:10.2166/washdev.2021.137
31. Dansou BS, Odoulami L. 2015. Factors of degradation of well water for domestic use in the Commune of Pobè in the South-East of Benin. Afrique SCIENCE, 11(6): 367–376.
32. Kelly ER, Cronk R, Kumpel E, Howard G, Bartram J. 2020. How we assess water safety: A critical review of sanitary inspection and water quality analysis. Science of The Total Environment, 718:137237. DOI: https://doi.org/doi:10.1016/j.scitotenv.2020.137237
33. Le Duc F & Vaurette D. "Bacteriological control of the potability of water. 2016. Ed. ACAUPED – Plévenon Trégor Solidarité Niger – Penvénan – 2nd Edition.
34. ZIRI MOHAMMED ABDERRAHMANE, (2014), "Eco-bacteriological and enzymatic study of some wetlands classified under the international Ramsar convention in the biogeographic region of Oran (Lake Telamine and Macta Lagoon) and Bechar (Djorf Dam) torba » Master's thesis in biotechnology from the University of Science and Technology of Oran Mohamed Boudiaf (Algeria)
35. Rabearisoa AH, Harinandrasana V, Rabearisoa H, Rakotozafy JCR, Razanamparany B, and Randimbiarison S N. Health risks related to the physicochemical and bacteriological quality of groundwater from Igaga , Fianarantsoa (Madagascar). Int. J. Biol . Chem . Sci . 17(7): 3037–3046, 2023. DOI: https://dx.doi.org/10.4314/ijbcs.v17i7.33
36. National Institute of Public Health of Quebec, 2004. Study of the risk of gastroenteritis in families using water from a domestic well; Study on the quality of drinking water in seven watersheds with excess manure and potential health impacts. Biological, Environmental and Occupational Risks Division National Institute of Public Health of Quebec and Public Health Research Unit CHUL Research Center (CHUQ).