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(RESEARCH ARTICLE)

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Physicochemical and microbiological quality of spring water consumed by the inhabitants of the districts of Madibou in Brazzaville, Republic of CONGO

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Abstract

The quality of spring waters in the district of MADIBOU located south of Brazzaville was evaluated by physicochemical and microbiological parameters measured in situ or in the laboratory. The waters from all springs studied are cleared and did not present an unpleasant smell. The survey conducted among the population in the study area showed that 70.5 to 85.33% of the inhabitants use spring water. The water springs directly from the surface of the ground through an opening made by the inhabitants of the district and appropriate containers are placed at this outlet to collect water which they use without any prior treatment. After sampling the spring water, several analytical methods were used to determine the different parameters. The results of these analyzes show that from a physicochemical quality, these waters are acidic with pH values which are not in the pH range of drinking water and contain amount of nitrates that largely exceed WHO standards, which constitutes a danger for the population that consumes these waters. On the microbiological level, we note the presence of total germs and total coliforms, and the absence of faecal coliforms. The consumption of this water without prior treatment is therefore not recommended ; before using this water, specific treatments must be carried out, for example pH correction with calcium hydroxide and disinfection with sodium hypochlorite.

Keywords: Consumption; Physicochemical; Microbiological; Spring water; Brazzaville

1. Introduction

Despite the abundance of rivers in the Republic of CONGO, the population has not sufficient quantities of drinking water. In the major cities of the country, the drinking water supply is provided by the LCDE, which is the only state company operating in this area and it is unable to meet the drinking water needs of the entire population. With the extension of the city, the problems of access to drinking water arise with great acuity, in particular in the peripheral districts and the inhabitants are obliged to find solutions to compensate for this lack of drinking water [1, 2]. With the recurrent power cuts and the absence of this company's distribution network in the outlying districts, the inhabitants of same districts consume the water of various origins such as spring water, swells drillings and rain depending on where they live. In Madibou located in the south of Brazzaville, the surveys carried out among the population showed that 75 to 95% of the inhabitants use spring water whose physicochemical and microbiological quality is not known. The consumption of this water without any treatment can be the cause of several waterborne diseases, especially for children. Knowledge of the physicochemical and microbiological quality of these waters raise awareness of the population on the dangers of consumption of these waters without any preliminary treatment, and makes it possible to propose some specific

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treatments that they can apply to improve the quality of the water before use [3, 4, 5]. Based on these survey results, we undertook research work on these spring waters to provide information to assess their physicochemical and microbiological quality.

2. Material and methods

The studies were carried out on spring waters located in four different districts of the Madibou, namely: Cataractes, Mafouta, Massissia and Faubourg.

The first step was to carry out a survey of the population to know the percentage of consumption of each type of water.

Figure 1 Gives the location of the various springs

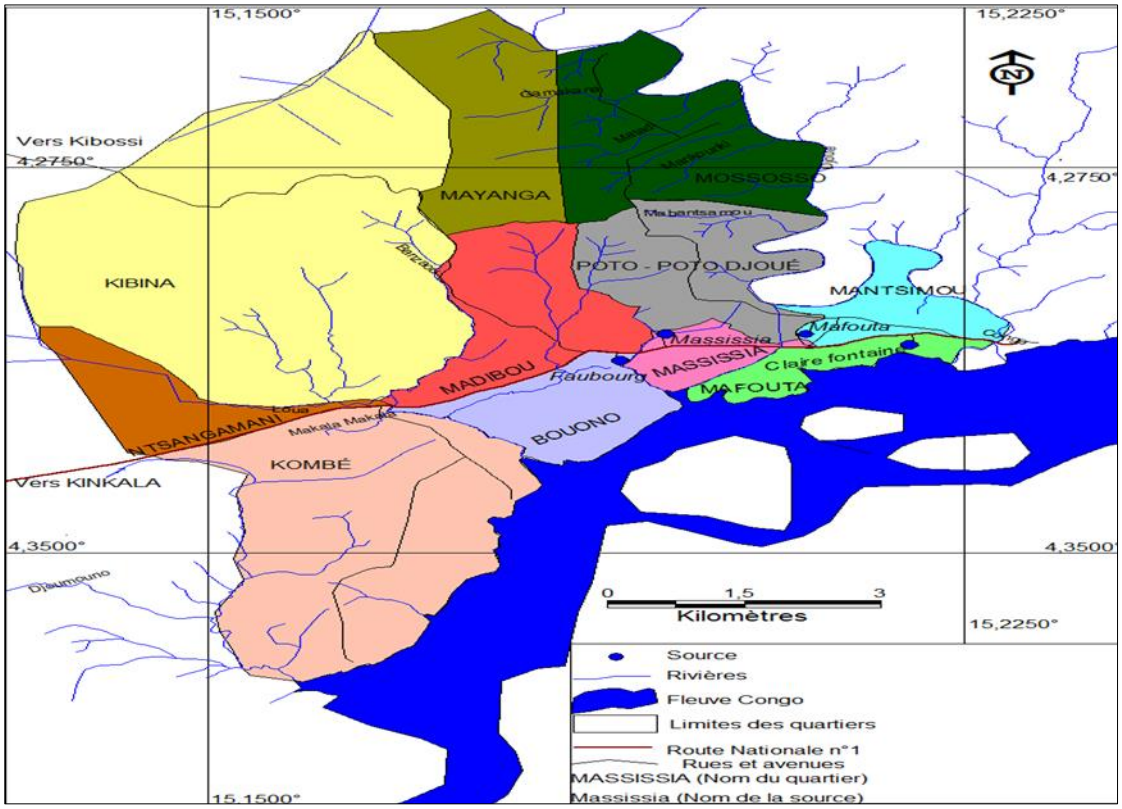


Figure 1 Location of water springs

After locating the springs most used by the population, their GPS coordinates were determined and are given in Table 1.

Table 1 GPS coordinates of the four water springs

Springs	Latitude	Longitude
Cataractes	15,21958	4,30954
Mafouta	15,20943	4,30734
Massissia	15,19540	4,30732
Faubourg	15,19092	4,31252

Figure 2 shows the pictures of the four spring waters concerned by this study

Cataractes spring water

Mafouta spring water

Massissia spring water

Faubourg spring water

Figure 2 Pictures of the four spring waters

The samples of water springs for the physicochemical analyzes were made in plastic bottles, well cleaned first with distilled water, with diluted nitric acid and then finally with the water to be analyzed. [6, 7]. The water sample for microbiological analyzes were taken in well-sterilized glass bottles to avoid any external contamination [8, 9]. For each spring, three samples were taken monthly in the period from May to July 2021 and the average of each parameter is given. After determining a few parameters in situ, the water samples were stored in coolers and then brought to the laboratory for analysis the same day. The different analysis methods are pH-metry, volumetry and colorimetry ; the following physicochemical parameters determined were: pH, conductivity, turbidity, complete alkalimetric (TAC), total hydrotimetric (THT) , Total dissolved salts (TDS), calcium, magnesium, nitrate, bicarbonate ions [8, 10] .

The pH, temperature and electric conductivity were measured with multiparmeter water quality meter EZ9909, the turbidity with turbidity mater ORIAN AQ3010 and the ions with a spectrophotometer Lamotte SMART.

The microbiological parameters determined are as follows: total coliforms, total germs, faecal coliforms [8].

3. Results and discussion

3.1. Consumption of water by district

A preliminary survey of the population of the different districts showed that the majority of the population use spring waters, which justify the need of the question on the physicochemical and microbiological quality of the water. Figure II gives the results of the survey

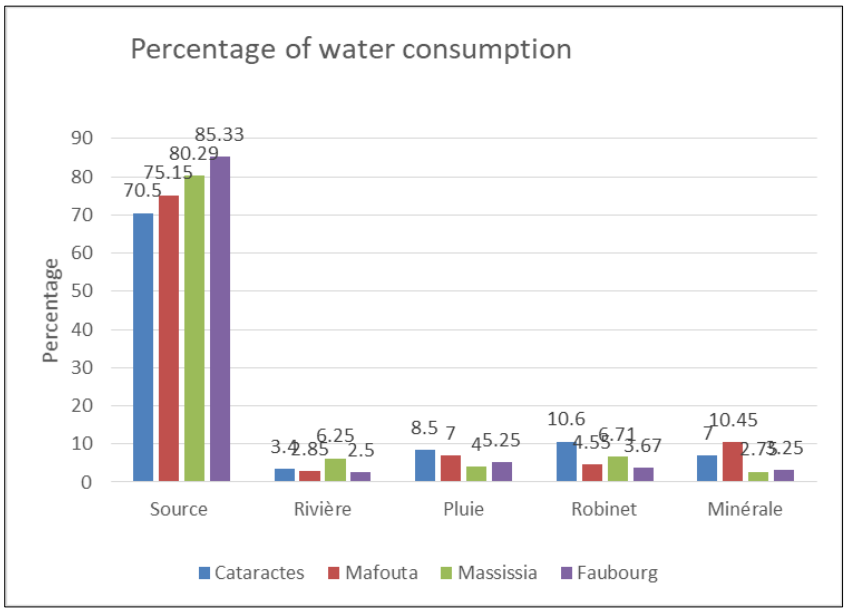
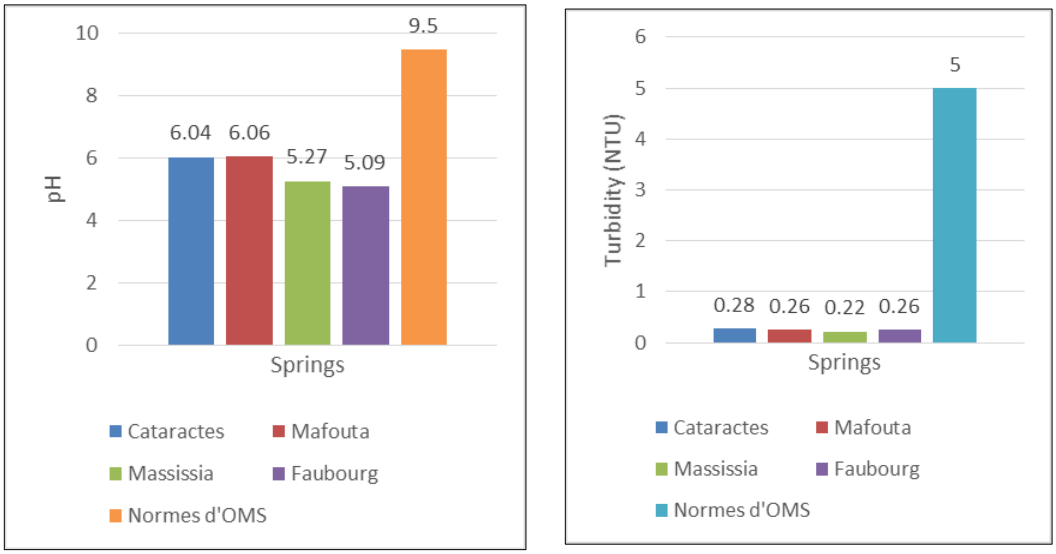


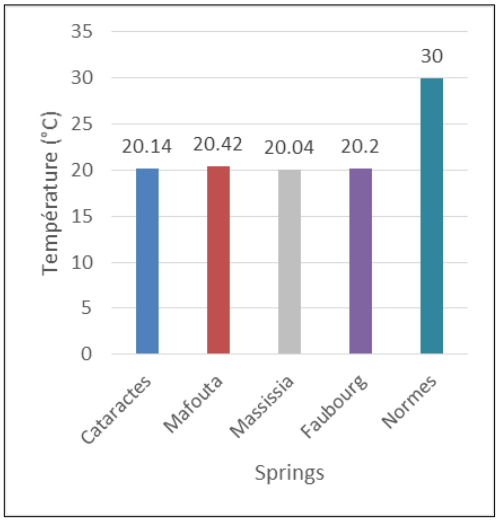
Figure 3 Percentage of water consumption by Madibou district

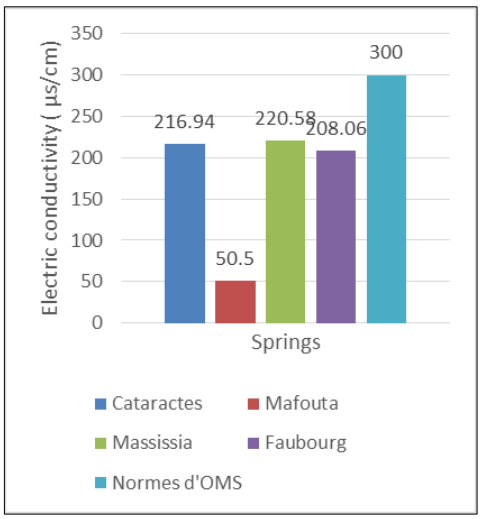
This histogram shows that more than 70 to 85% of the population uses spring waters. Except the spring water which is the most consumed, the population also uses rain waters, tap waters and mineral waters.

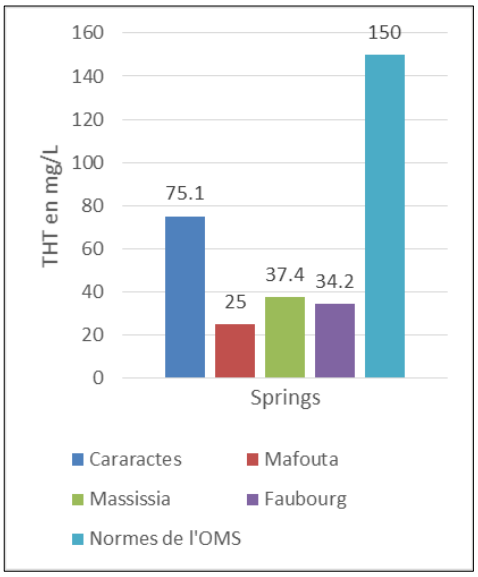
3.2. Physicochemical parameters

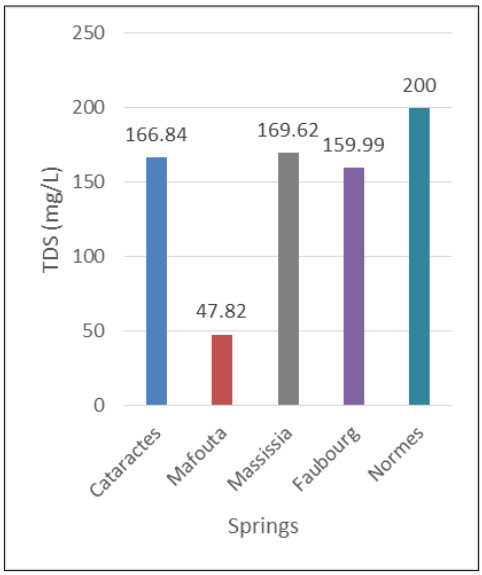
The results of the physicochemical analyzes of the waters of the four spring waters studied are given by the following histograms (Figure 4)

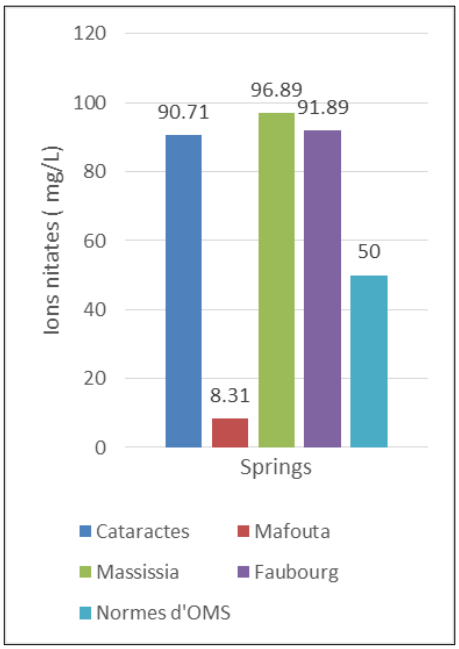


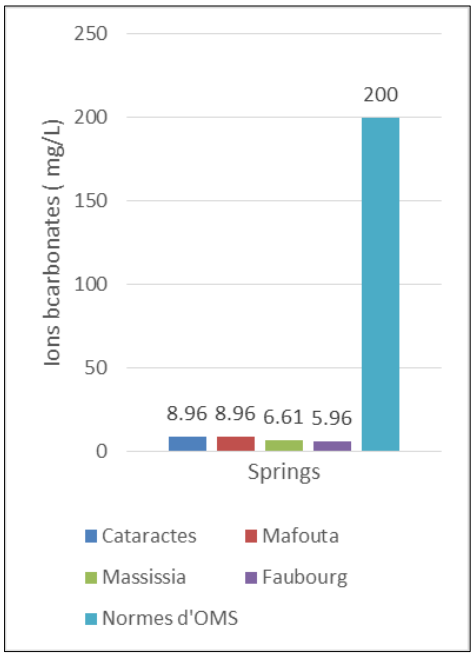

Température (°C)
35
30
25
20
15
10
5
0
20.14
20.42
20.04
20.2
30
Cataractes
Mafouta
Massissia
Faubourg
Normes
Springs


Electric conductivity (µs/cm)
350
300
250
200
150
100
50
0
216.94
50.5
220.58
208.06
300
Springs
Cataractes
Mafouta
Massissia
Faubourg
Normes d'OMS


THT en mg/L
160
140
120
100
80
60
40
20
0
75.1
25
37.4
34.2
150
Springs
Cararactes
Mafouta
Massissia
Faubourg
Normes de l'OMS


TDS (mg/L)
250
200
150
100
50
0
166.84
47.82
169.62
159.99
200
Cataractes
Mafouta
Massissia
Faubourg
Normes
Springs


Ions nitates (mg/L)
120
100
80
60
40
20
0
90.71
8.31
96.89
91.89
50
Springs
Cataractes
Mafouta
Massissia
Faubourg
Normes d'OMS


Ions bcarbonates (mg/L)
250
200
150
100
50
0
8.96
8.96
6.61
5.96
200
Springs
Cataractes
Mafouta
Massissia
Faubourg
Normes d'OMS

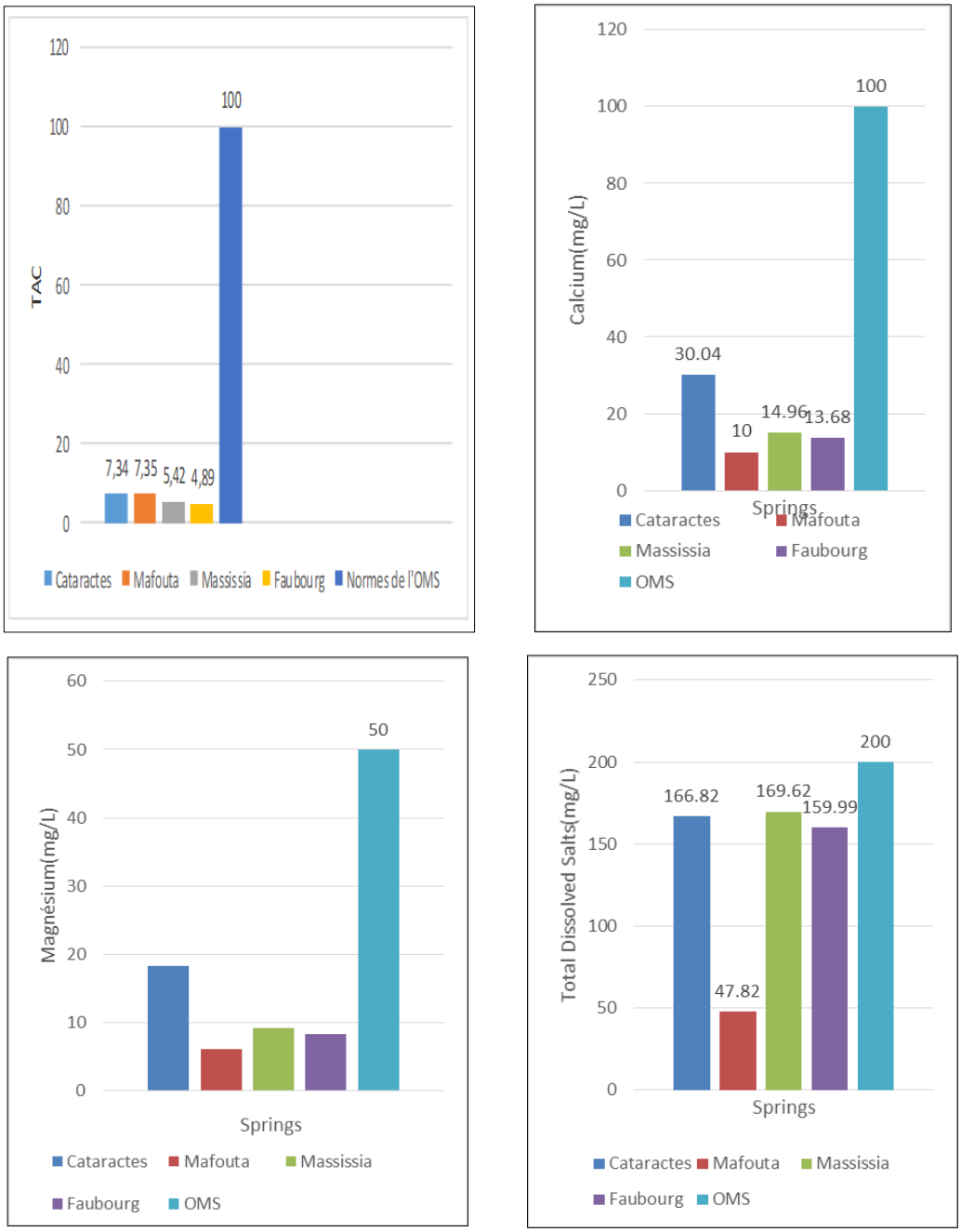


Figure 4 Histogram of parameters measured

The pH makes it possible to evaluate the acidity of the water and according to the WHO standards on drinking water, its value must be between 6.5 and 8.5 [10]. The pH value also makes it possible to evaluate the aggressive nature of water. It is influenced by the nature of the ground crossed and by human activities [11, 12]. Indeed the presence of CO_2 contained in the air can also influence the pH of the water following the formation of carbonic acid with the consequence of reducing the pH. That's why we must measure the pH of the water in-situ to avoid such a reaction. The waters of all the spring waters studied have valued below 6.5, which show that they do not comply with WHO standards for this parameter. Before drinking this water, the pH value must be corrected by added calcium hydroxide.

Temperature is a parameter that affects many chemical and biological reactions and influences other parameters such as conductivity; it is greatly influenced by the ambient temperature. The spring water temperatures studied are between 20.04 and 20.42 and all comply with WHO standards. In general, the temperature of spring water is lower than that of surface water which is subject to variations in ambient temperatures.

The law average value of the turbidity of these spring waters indicates that they are not turbid and do not contain colloidal and suspended mater as value between 0.22 and 0.26 NTU which are all below 5 NTU which is the limit value in the WHO standard. The low turbidity show that these waters are very clear.

The conductivity of water reflects its capacity to carry current and it is a function of the concentration of all the dissolved elements present in the water and of the temperature. The greater amount of dissolved elements explain the higher conductivity. The conductivity values are between 50.50 and 216.94 µS/cm indicate that these waters are weakly mineralized and this parameter varies in the same direction as the general mineralization and the Total dissolved Salts (TDS) [13, 14].

The concentration of bicarbonate ions in the water is a function of the carbon dioxide pressure and depending on this water can be aggressive and dissolve the calcium carbonate. Their concentrations in the spring waters studied vary between 5.96 and 8.96 mg/L and these values are very low compared to WHO standards.

The other physicochemical parameters measured have valued that comply with WHO standards, in particular calcium ions (10 to 30.04 mg/L), magnesium ions (6.07 to 18.25 mg/L), general mineralization (55.32 to 167.64 mg/L), TDS (47.82 to 169.62 mg/L), THT (25 to 75.1 mg/L $CaCO_3$) and finally TAC (4. 89 to 7.35 mg/L $CaCO_3$).

However, the great concern related to the consumption of spring water of the Cataractes, Massissia and Faubourg springs are linked to the high concentrations of nitrate ions which are respectively 90.71; 91.89 and 96.89 mg/L and greatly exceed the WHO standards which set the maximum concentration of this ion at 50 mg/L. In the presence of reducing agents, nitrate ions can be reduced to nitrite ions which are more toxic. The high concentrations of nitrate ions in these waters may be due to the use of mineral fertilizers because a strong agricultural activity with the use of fertilizers are developing in this area [15]

The results of the physicochemical analyzes show that the waters of all these sprins are not the best quality and can cause waterborne diseases to the population who consume them without any preliminary treatment. Of all these determined parameters, only pH and nitrate ions do not meet WHO standards for drinking water.

3.3. Microbiological parameters

The results obtained are given in the following tables.

Table 2 Microbiological parameters of the springs water

Parameters	Units	Average values				WHO standards
		Cataractes	Mafouta	Massissia	Faubourg	
Total germs (24h at 37°C)	UFC	0	0	0	60	0 - 30 UFC/100mL
Total coliforms (24h at 37°C)	UFC	0	0	0	20	0 UFC/100mL
Faecal Coliforms (48h at 44°C)	UFC	0	0	0	0	0 UFC/100mL

It appears from this table that the waters of the Cataractes, Mafouta and Massissias springs have good microbiological quality since they do not contain the microorganisms sought. On the other hand, water from the Faubourg spring which contains total germs and total coliforms at average values of 60 and 20 CFU/100 m respectively are not the best quality. The use of water from this spring requires prior disinfection, for example with sodium or calcium hypochlorite [16, 17, 18].

4. Conclusion

The study conducted during this work aims to determine the quality of spring water of the districts of Madibou, located in south of Brazzaville intended for human consumption. The results of the analyzes showed that:

- From the organoleptic quality, the waters of the four springs are clear and have no unpleasant smell or taste;
- From a physicochemical quality, the waters of the four springs have pH values lower than those set by the WHO standards for drinking water, and high concentrations of nitrates ions.

With the exception of the Mafouta spring, the waters of three other springs (Cataractes, Massissia and Faubourg) contain large quantities of nitrates which exceed WHO standards. These results show that these waters are poor in physicochemical quality since all the parameters do not comply with WHO standards. Their use therefore constitute a risk to human health.

- From the microbiological quality, the results of the analyzes showed the absence of faecal coliforms in the four springs, as well as the absence of total germs and total coliforms in the waters of the Caratactes, Mafouta and Massissia springs water. The waters of these three springs are therefore of good in microbiological quality. On the other hand, the waters of the Faubourg spring, the presence of total germs and total coliforms was not average concentrations respectively to 60 and 20 CFU/100 ml, which indicates a poor microbiological quality of the waters of this spring which can harm human health.

This study showed that the water from the four sources deserves specific treatments before their consumption by the population to avoid waterborne diseases. the treatments must aim at pH correction, elimination of nitrate ions and disinfection with sodium or calcium hypochlorite to prevent waterborne diseases in the population.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest between the authors of this article.

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