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Comparative Study of Physicochemical and Bacteriological Parameters of Water Packaged in Sachets and Tap Water in Niamey City

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ABSTRACT

In Niamey city, in recent years, there has been a proliferation of drinking water packaged in sachets. Thus, to assess the quality of this water in sachets, a comparative study of the physicochemical and bacteriological parameters of tap water and water packaged in sachets from the city of Niamey was carried out. This study was realized after a survey of manufacturers of water in sachets followed by a sampling series which consisting of 15 water samples of tap water and 24 water samples of water in sachets. The results of this study showed that the physicochemical parameters values of water packaged in sachets were almost identical to those of tap water, but lower than the values recommended by OMS. The microbiological analysis according to the membrane filtration method shows the absence of total germs and Escherichia coli in all the samples of tap water, while 15 of the 24 samples of water packaged in sachets, i.e. 62.5%, showed the presence of total germs and absence of Escherichia coli. This is linked to the poor hygienic quality of the packaging of this water in sachets.

1. INTRODUCTION

Water that is the main source of life, is one of humanity's most critical natural resource problems. During a long time, this water, which was considered unalterable and inexhaustible, has nowadays become one of the most precious natural resources that deserves all attention. Given the importance of water as a vital resource, people must be guaranteed safe access to good quality water for cooking and hygiene, as well as for basic production, for example farming. [1], [2]. The evaluation of water quality generally requires the determination of various parameters such as physicochemical and biological parameters of water [3], [4]. Water quality is often related to the degree of bacterial contamination. Drinking water distribution systems are colonized by saprophytic heterotrophic microorganisms that grow on biodegradable organic matter [5]. Indeed, in most underdeveloped countries, the population is confronted with the problem of water in quantity and quality. The consumption of poor quality water is in most cases the cause of many waterborne diseases such as cholera disease. In these underdeveloped countries, in general the population of urban areas consumes drinking water from public network. In addition to tap water, the sale of water in sachets has developed considerably in these countries. However, these tap and packaged waters can often be contaminated with chemical and bacteriological pollutants [6].

Many research has been carried out about tap water and packaged water quality around the world. In Ghana, the work carried out by [7] to determine the microbiological quality of different types of tap water and packaged drinking water available in Accra by using bacteriological and parasitological analyses results showed that two out of the five tap water and 31 out of the 60 sachet water samples had a wide range of protozoa including rotifers. In Tanzania, the work realized [8] to assess the physicochemical quality of bottled and tap water in Dar es Salaam showed a great variation in the physicochemical quality of bottled water, with some samples exceeding the Tanzania Drinking Water Quality Standards for nitrate, pH and lead. In addition, it was observed that the mean concentration values of TDS and nitrate in tap water were found to be significantly lower than those of bottled water. Kuala Lumpur, the work carried out by [9] to survey the tap water quality demonstrated that there was no microbial contamination in 100 random samples collected from 20 selected areas. In addition, parameters such as color, pH, turbidity, hardness, magnesium, sulfate and chloride were within acceptable limits.

The city of Niamey is supplied by the distribution network of Water Exploitation Company of Niger (SEEN) which produces drinking water from the Niger River. But, in recent years, there has been a galloping proliferation of a variety of waters packaged in sachets. These waters packaged in sachets have met with great success because they are practical, refreshing and inexpensive for low-income inhabitants. The controversies about the quality of these waters in sachets have not ceased to be a worrying subject, a real health issue, despite their appearance, waters in sachets are far from being blameless waters.

The purpose of this study is to realize a comparative study of the physicochemical and bacteriological parameters of tap water and water packaged in sachets from the city of Niamey, in order to help the population for a better choice of water quality for consumption.

2. MATERIALS AND METHODS

2.1 Study Area

The region of Niamey is located in the southwest of Niger between the parallels 13 ° 28 'and 13 ° 35' north latitude and the meridians 02 ° 03 'and 02 ° 12' east longitude. It covers an area of 239 km2. This region is located to the north by the municipalities of Karma and Hamdallaye, to the east by the municipalities of Liboré and Hamdallaye, to the south by the municipalities of Liboré and Bitinkodji and to the west by the municipality of Bitinkodji. The Niger River divides Niamey into two distinct parts (right bank and left bank) and two bridges currently connect the two banks. Most of the population is located on the left bank which totals 4 of the 5 districts of Niamey while the 5th district occupies the right bank (Figure 1). The climate of this region falls within the regional framework of that of the Sahelian tropical strip. In the Niamey region, more than a third of precipitation falls with an intensity greater than 50 mm.h-1, and more than half of the annual rainfall total falls in less than 5 hours [10]. The annual average temperature of this region is 29 ° C. The maximum temperature recorded during the day can reach 45 ° C in the shade at the end of the dry season (in April).

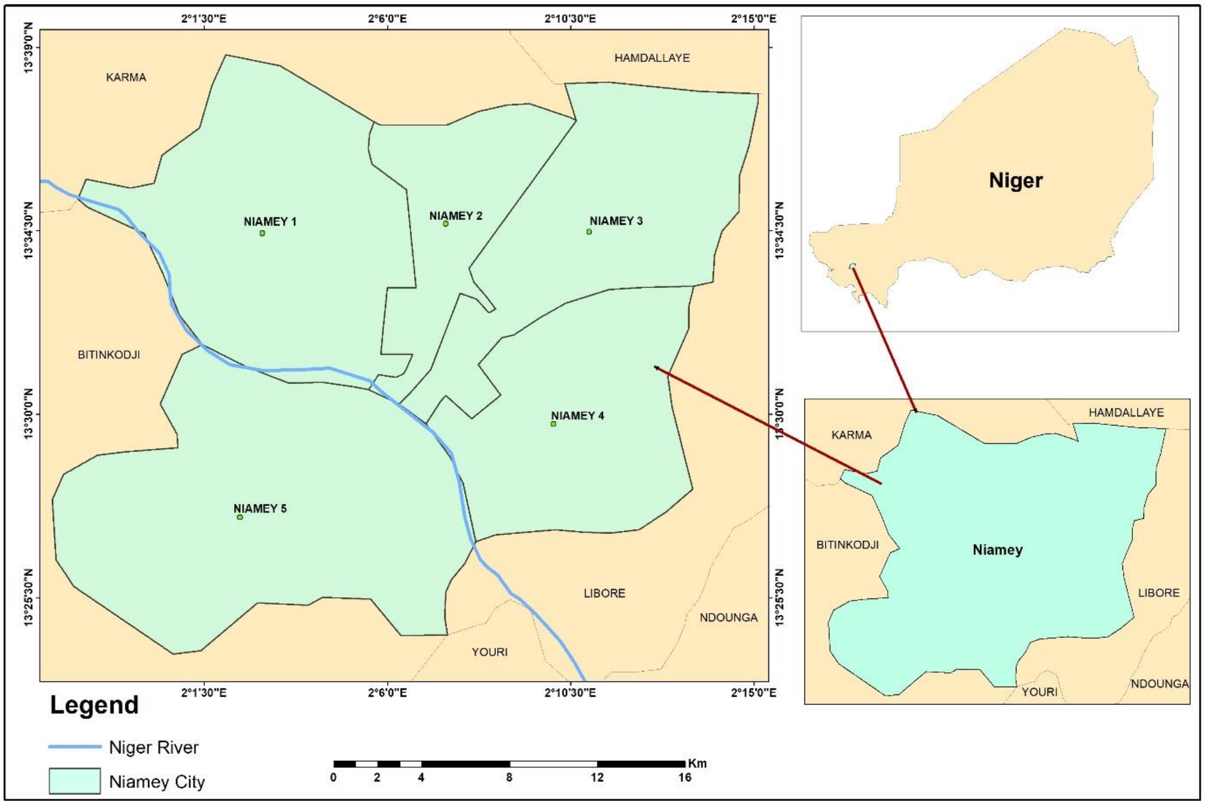

Figure No. 1: study area

2.2 Sampling

The present study which concerns all the districts of Niamey city was the subject of health surveys with manufacturers of water in sachets followed by a series of sampling composed of 15 samples of tap water and 24 samples of water in sachets. For tap water of each site, an identical attitude for sampling was adopted; first, we let the first liters of water flow after having cleaned the spout of the tap with 90° alcohol then we burnt the spout of the tap with a blowtorch, and we fill under the flame of the blowtorch a sterilized bottle of 500 mL so as not to let the flame pass through the water during filling because it will destroy all the micro-organisms that the water contains. Thus, the tap water samples were collected from different districts of Niamey. For water packaged in sachets, before sampling, a series of investigations were carried out in the study area for identifying the methods and conditions under which the water is put into sachets. After this investigation, 8 points were sampled.

2.3 Physicochemical analyzes

The following table presents physicochemical parameters of water samples determined according to the methods used for each parameter.

Table No. 1: parameters determined according to the used method

Méthodes	Spectrophotométrie	Volumétrique	Diverses
Paramètres	Couleur, MES, Chlore résudiel SO_4^{2-}, NO_3^-, NO_2^-	TAC, TA, TH, MO	CE, TDS, pH

3. RESULTS

3.1 Results of physicochemical analyzes

In this part, the physicochemical parameters analysis results were given with indexing of certain parameters.

3.1.1 Hydrogen potential (pH)

The pH (Hydrogen potential) is a parameter that measures the concentration of H^+ ions in the water. It thus translates the balance between acid and base on a scale of 0 to 14. The pH makes it possible to determine the aggressiveness of the water. The following Figure 2 represents the distribution of pH value of tap water samples and water packaged in sachets:

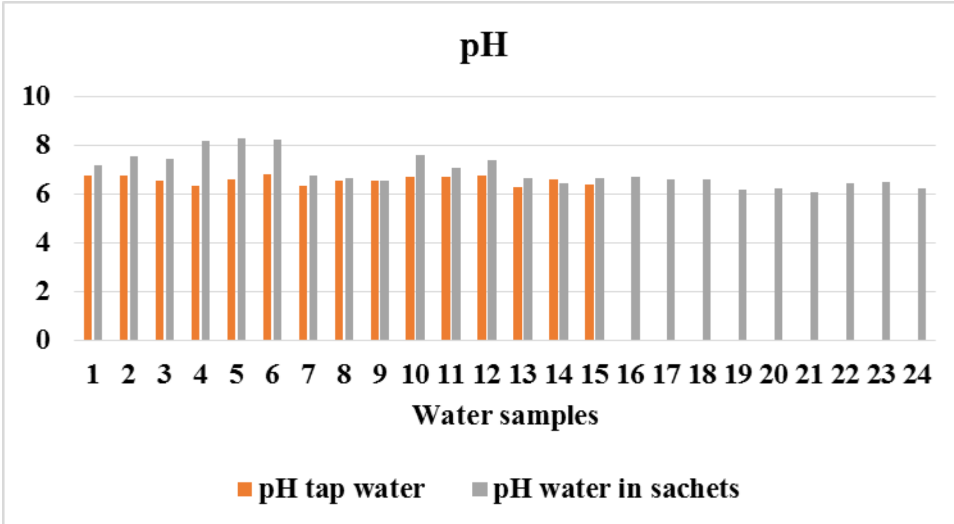

Figure No. 2: pH of water samples

The pH values for tap water are between 6.3 and 6.8 while for water packaged in sachets these are between 6.05 and 8.3. These results are consistent with WHO standards (6.5-8.5) [11]. This situation is due to the fact that the majority of water in sachets in the city of Niamey comes directly from the national distribution network.

3.1.2 Conductivity

Conductivity represents one of the means of validating the physicochemical analyzes of water. Conductivity is used to assess the number of dissolved salts in water [12]. The conductivity values of collected water samples from the study area are illustrated in the following Figure 3:

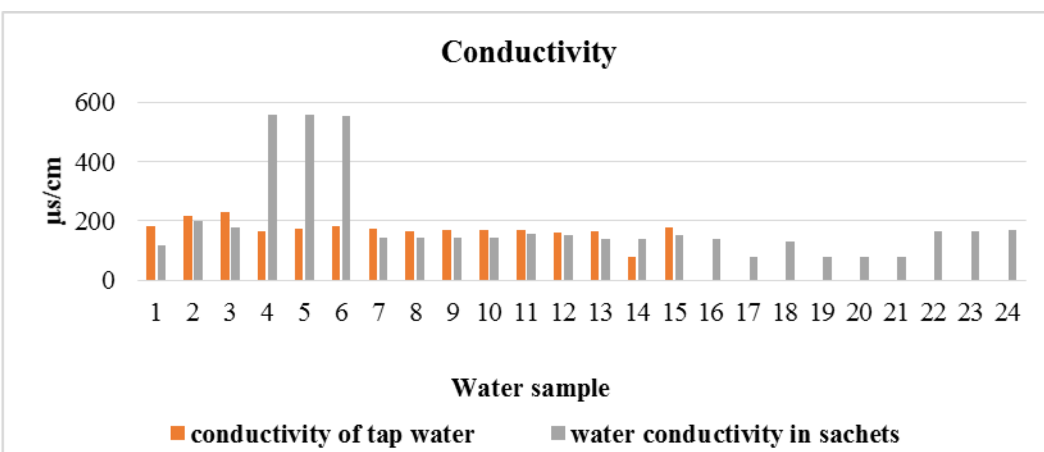

Figure No. 3: Conductivity of water samples

The values recorded after the analysis are less significant, thus the values for tap water are between 77 and 231 µs/cm and those of water in sachets varied between 77 and 558 µs/cm. These results are consistent with those of the WHO standard (400µs/cm) and reflects a low mineralization of these waters that come from surface water sources. It is also noted that the conductivity values of samples number 4, 5, and 6 are higher than theses recommended by WHO standards due to the fact that these water samples were collected from highly mineralized borehole.

3.1.3 Turbidity.

Turbidity is an organoleptic parameter. It is an expression of the optical properties of water to absorb and/or scatter light. It is due to the presence of finely divided suspended matter such as clays, silts, etc.

The turbidity values of collected water samples are presented in the following Figure 4.

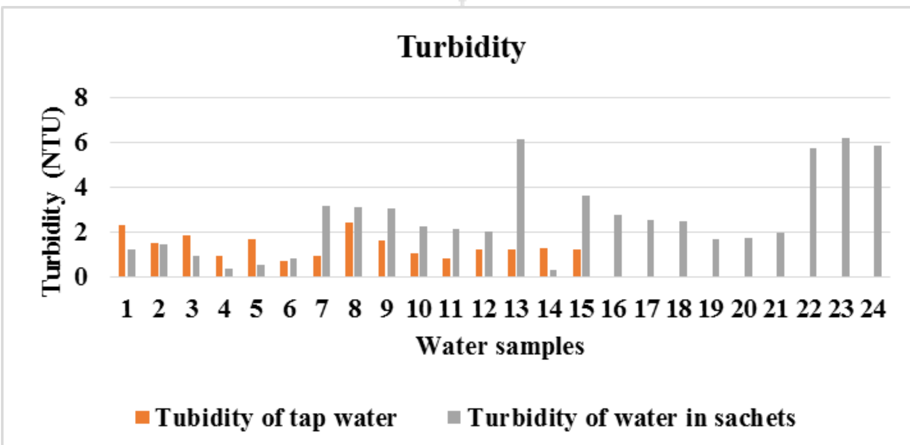

Figure No. 4: Turbidity content of water samples

According to the results, the turbidity values of tap water are between 0.72 and 2.41 NTU and those of bagged water between 0. 34 and 6.12 NTU. This situation highlighted that almost the same results for tap water and bagged water. It was observed also that turbidity values of all tap water samples are consistent with WHO standards (< 5 NTU). This situation is due to good filtration during the treatment of drinking water. However, for some samples of water samples from sachets, the turbidity values are higher than WHO standards. These high values observed in certain samples of water in bags are related to the lack of maintenance of the bagging line and especially to the storage conditions of the water before it is bagged.

3.1.4 Nitrates

Nitrates are the salts of nitric acid. The chemical formula of the nitrate ion is NO_3^- . The presence of nitrates in water is an indicator of pollution of agricultural origin (fertilizer), urban (dysfunction of sanitation networks) or industrial. The NO_3^- values of tap water and bagged water are given in the following Figure No 5:

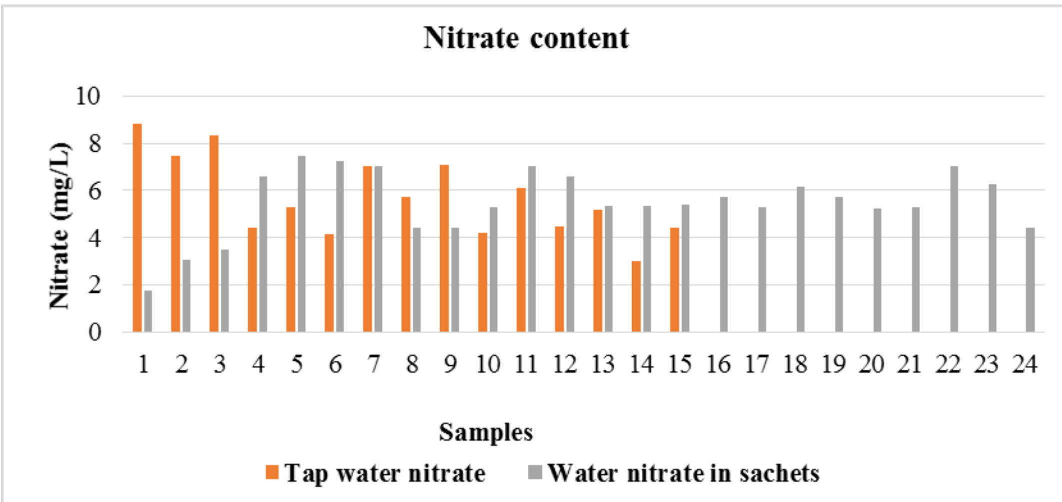

Figure No. 5: Nitrate content of water samples

The analysis of this histogram (Figure 4) shows us that the nitrate contents for tap water are between 3.02 and 8.8 mg/L and those of water in sachets varied between 3.08 and 7.48 mg/L. These insignificant values NO_3^- observed in all water samples are below the WHO standard which is around 50 mg/L. In the presence of oxygen NH_4^+ undergoes rapid oxidation to NO_3^- [13]; [14]; [15]. The low nitrate levels observed in all water samples could be explained by the absence of intensive agricultural and industrial activities around the Niger river which is the main reservoir that treats water for consumption in Niamey city, and the majority of water samples of sachets come from national drinking water network.

3.1.5 Nitrites

Nitrites are the least oxidized form of nitrogen; its concentration must not exceed 0.1 mg/L according to WHO (2011) recommendation for water intended for human consumption. The nitrite values of collected water samples are presented in figure No 6:

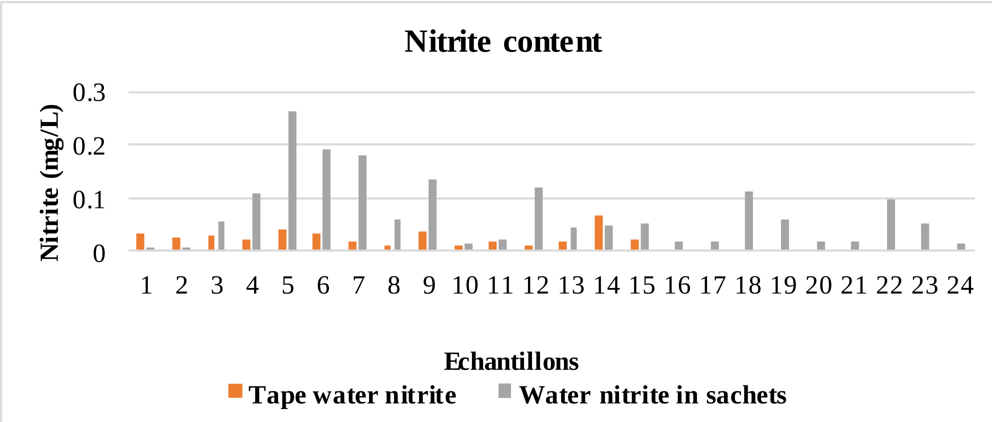

Figure No. 6: Nitrite content of water samples

According to Figure 6, the nitrite concentrations for tap water are between 0.01 and 0.066 mg/L and those of water in sachets varied between 0.0066 and 0.2607 mg/L. It is observed that all tap water samples have a nitrite content lower than the WHO standard. However, water samples number 5, 6, 7 and 9 which come from bagged water samples have NO_2^- values higher than the recommended value by WHO standard which is 0.1 mg/L. The high values of NO_2^- observed in these samples comes from the reduction of the nitrogen contained in these samples (nitrates) into nitrites under the influence of a denitrification action caused by bacteria of the genus Nitrosomonas.

3.1.6 Sulfate content

The natural origins of sulfates are rainwater and the dissolution of evaporitic sedimentary rocks, in particular gypsum ($CaSO_4$), but also pyrite (FeS). The anthropogenic origins are the combustion of coal and oil which leads to a significant production of sulfides (found in the rains), and the use of chemical fertilizers and washing powder.

The SO_4^{2-} values of all water samples collected in the study area are presented in the following Figure No 7:

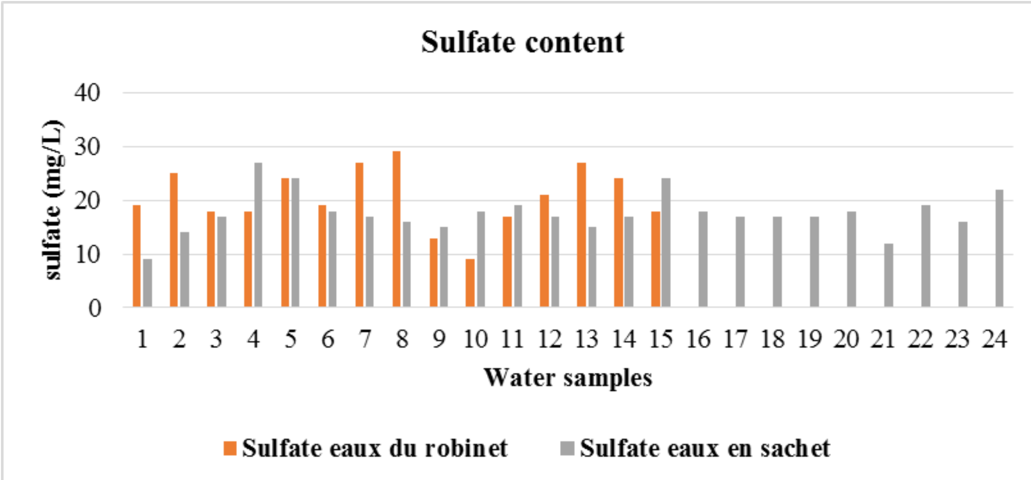

Figure No. 7: Sulfate content of water samples

According to Figure 7, the sulfate contents of tap water range between 9 and 29 mg/L and those of water in sachets are between 9 and 27 mg/L. According to WHO standard, all water samples have SO_4^{2-} values lower than recommended value which is 400 mg/L. The sulfate contents of all water samples from the study area are essentially due to the addition of aluminum sulfate as a reagent in the treatment of drinking water.

3.1.7 Organic matter

Organic materials promote the appearance of bad tastes which could be exacerbated by chlorination. The organic materials of water samples from tap water packaged water are presented in the following Figure No 8:

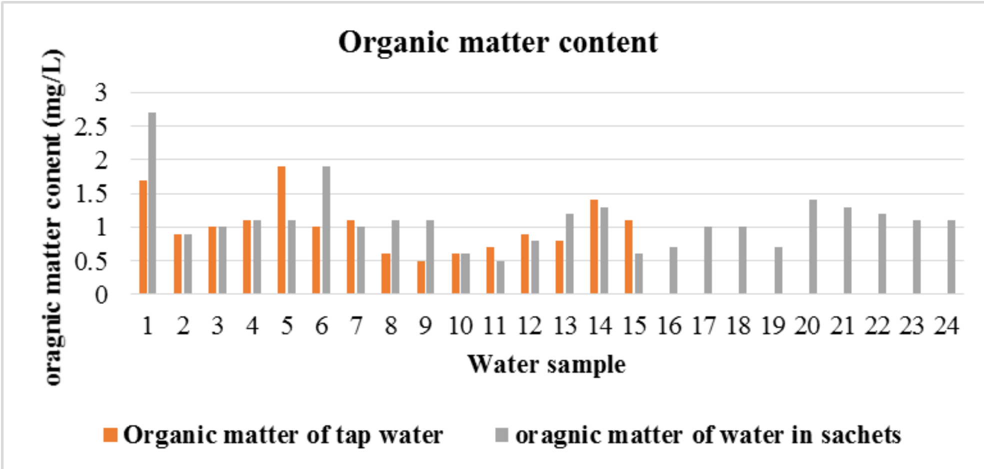

Figure No. 8 : Organic matter content of water samples

According to Figure No 8, the organic matter contents of tap water samples are between 0.5 mg/L and 1.9 mg/L while those of water samples from sachets varied between 0.5 mg/L and 2.7 mg/L. Since the WHO standard is set at 5 mg/L, the organic matter content of all tap water and packaged water samples are within the recommended values. These low values are dues to the effectiveness of the treatment of drinking water by the SEEN.

3.2 Results of bacteriological analyzes

In this paragraph, it is expressed the relationships between bacteria and residual chlorine content. This study consists of looking for two germs, namely total germs and Escherichia coli. In all carried out bacteriological analyzes none revealed the presence of the Escherichia colis type bacteria.

3.2.1 Results of bacteriological analysis for tap water

Cultivated on their specific culture medium and after incubation for 24 hours at 440 ^{o}C for E-Coli and 370 ^{o}C for total germs, the results of colony counting are presented in the following table (Table 2).

Table No. 2: direct analysis after incubation of tap water samples

Echantillons	Germes totaux	E Colis	Chlore résiduel
R1	0	0	0,81
R2	0	0	0,48
R3	0	0	0,48
R4	0	0	0,19
R5	0	0	1,2
R6	0	0	0,8
R7	0	0	1,24
R8	0	0	0,79
R9	0	0	0,37
R10	0	0	1,07
R11	0	0	0,74
R12	0	0	0,63
R13	0	0	0,6
R14	0	0	0,12
R15	0	0	0,97

After incubation, no germs were detected in all the tap water samples. This is actually due to the presence of the amount of residual chlorine that prevents further contamination in the distribution network.

3.2.2 Bacteriological analysis results for water in sachets

Seeded on their culture medium, tergitol TTC for E Coli and standard TTC for total germs and after incubation for 24 hours at 440 ºC for E Coli and at 370 ºC for total germs, the obtained results after counting the number of colonies are presented in Figure No 9 and Table No 3.

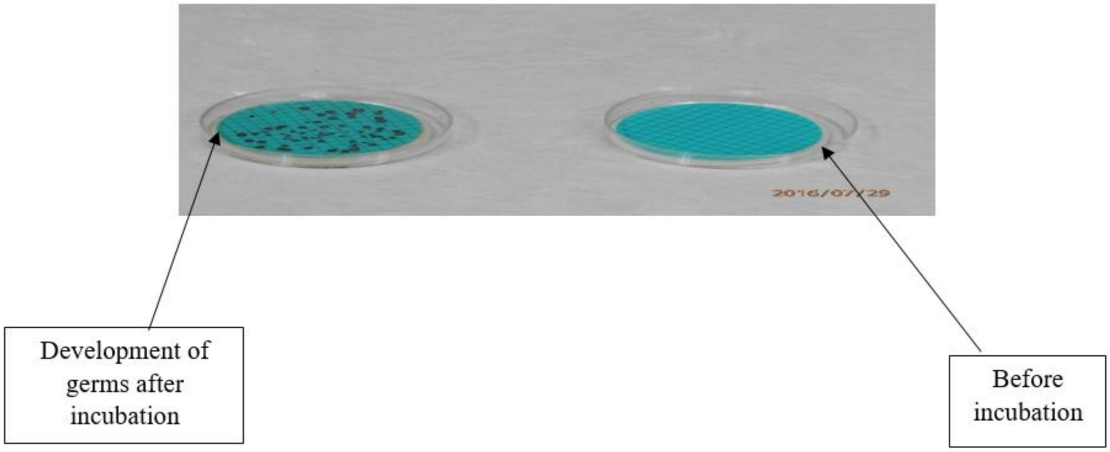

Figure No. 9: Sprout development

According to Table No 3 no E coli bacteria were detected, and 15 out of 24 samples were proved after incubation with positive result for total germs, this is due to the absence of chlorine in these samples and poor bagging conditions.

Table No. 3: direct analysis after incubation of water samples in sachets

Samples	Total germs	E Colis	Residual chlorine
1	0	0	0
2	0	0	0
3	0	0	0
4	>100	0	0
5	>100	0	0
6	>100	0	0
7	0	0	1,2
8	0	0	1,05
9	0	0	1,08
10	0	0	0,94
11	0	0	1,17
12	0	0	0,95
13	12	0	0,37
14	>100	0	0

15	60	0	0
16	47	0	0
17	13	0	0
18	7	0	0
19	3	0	0
20	2	0	0
21	2	0	0
22	2	0	0
23	2	0	0
24	3	0	0

The relationship between the residual chlorine content and the evolution of total germs is presented in Figure No 9. According to this Figure 10, there is a close relationship between the residual chlorine content and the evolution of total germs and all the samples of water that sachets have developed a positive result for bacteriology have a zero residual chlorine content. In addition, samples number 4, 5, 6 and 14 showed total germs greater than 100. Also, these results were explained by the poor hygienic conditions of the place of bagging The Figure 10 taken on a water packaging site in sachets, during this health survey in the study area, clearly shows a deleterious environment for the placing of water in sachets and a poor quality of the pipes. In addition, it was observed an absence of filters at the level of three (3) filter boxes.

The World Health Organization (WHO) sets the maximum number of coliforms allowed in drinking water at 0 coliforms per 100 mL of water. The classification of water established by the WHO in 1992 according to its quantity of coliforms highlights three classes:

- class I: good quality water; the number of coliforms is equal to 0 coliforms per 100mL;
- class II: less good water; the number of coliforms is between 10 to 100 coliforms per 100 mL. The water of this class is polluted and should only be used after appropriate treatment;
- class III: poor quality water; in this type of water, the number of coliforms is greater than 100.

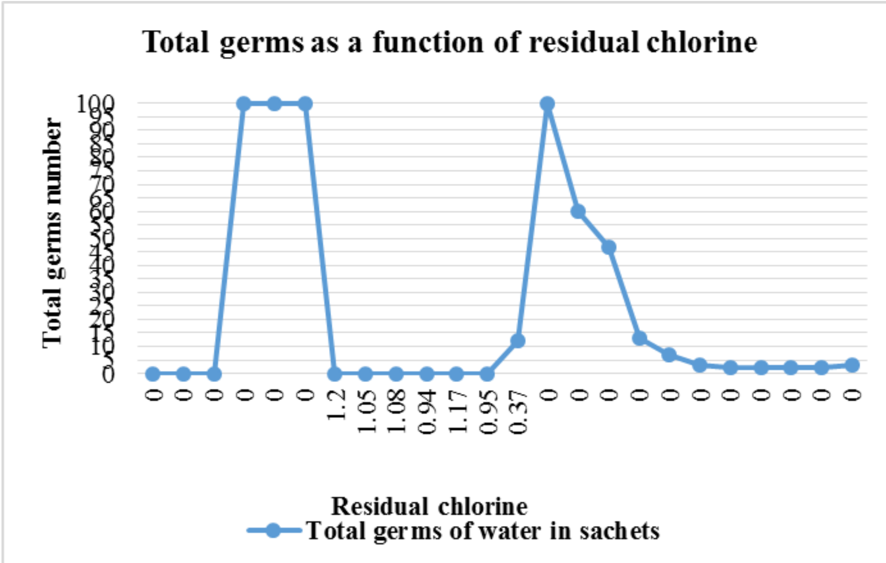

Figure No. 10: Evolution of total germs as a function of residual chlorine

Figure No. 11: Water bagging site in Harobanda

4. CONCLUSION

This study seeks to realize a comparative study of the physicochemical and bacteriological parameters of tap water and water packaged in sachets from the city of Niamey. The physicochemical analyzes results of water samples showed that tap water and water packaged in sachets are weakly mineralized, with values of physicochemical parameters for the most part below the standard of portability set by the WHO, with the exception of some water samples packaged in sachets. The bacteriological analysis results of tap water showed the absence of faecal coliforms (Escherichia coli) and total germs in all analyzed samples. For water packaged in sachets, bacteriological analysis revealed the presence of total germs in the majority of samples and 0 faecal coliforms detected.

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