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# Hygienic Quality of Water in Plastic Sachets Sold in Three Markets in the City of Yaounde

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## Abstract

With the expansion of the city of Yaoundé and the population growth, the supply of drinking water is very insufficient. The populations are increasingly starting to consume water in sachets. In the absence of strict regulation and rigorous control, the consumption of this water exposes the population to several inconveniences. This work consisted of conducting a study on the assessment of the health risks linked to the consumption of water in plastic sachets sold at three markets in the city of Yaoundé. These are the Ekounou, Biye-mAssi Accacia and Mokolo markets. To achieve this, samples were taken and subjected to physicochemical and bacteriological analyses. The results show that the ions $NO^{3-}$, $Cl^{-}$, $NH^{4+}$, $Ca^{2+}$, $Mg^{2+}$ are present in our samples and their concentrations comply with the standards. The bacteriological analysis reveals the absence of coliforms and fecal streptococci. The contents of the elements listed on the packaging of the samples were not found experimentally. The pH and conductivity measurements indicate that these waters meet the standards. However, the precarious hygiene conditions around the points of sale are the cause of the questionable quality of these waters.

## Keywords

Health Risk, Water, Plastic Bags, Physico-Chemical Analysis, Bacteriological Analysis, Yaoundé Market

## 1. Introduction

It is recognized that water has beneficial effects on the body because, the human body is made up of approximately 65% water, it needs at least 1.5 liters of water per day [1]. Due to its essential nature, water must be potable and of good quality to ensure the health of individuals and the population in order to avoid water-borne diseases such as cholera and diarrhea [2]. However, population growth poses

a challenge related to the availability of water in terms of quality and quantity that is capable of meeting the ever-increasing demand. With this in mind, Cameroon has undertaken to liberalize the water sector through laws governing the exploitation of spring water and mineral water [3]. This has led to the proliferation of bottled and plastic bag water production units. These waters, packaged in sachets and often iced, are offered at various points of sale in urban areas in general and in the city of Yaoundé in Cameroon in particular. They are therefore very accessible and refreshing.

The affordable price attracts people who need constant refreshment and who opt for these sachets over other types of packaging, such as breakable or non-breakable bottles. Sachet water is often sold in precarious conditions. Low and middle income populations prefer these sachets to tap water supplied by the semi-public water treatment company (CAMWATER). The lack of hygiene and the questionable quality observed around these waters mean that the risks of waterborne infections are serious and remain frequent [2]. According to S. Barbe *et al.*, 2018; 2.6 million people worldwide die each year due to diseases caused by water and an unsanitary environment [4]. In Cameroon, very few studies have been carried out on the quality of water contained in plastic bags [5] [6]. In view of these findings, markets being places of high human concentrations, the study aims to control the physicochemical and bacteriological parameters of water in bags consumed in certain markets in the city of Yaoundé in Cameroon. Thus, the general objective of the study is to evaluate the health risks linked to the consumption of water in bags in three markets in the city of Yaoundé. We will present the results of the field survey carried out among sellers of water in plastic bags and the physicochemical and bacteriological analysis of these waters.

## 2. Study Framework, Materials and Methods

### 2.1. Study Framework

This study was conducted in the Yaoundé metropolitan area (**Figure 1**), the capital of Cameroon and the administrative center of the Central Region. It is located 200 km from the Atlantic coast, at 30˚52 north latitude and 11˚32 east longitude, at an altitude of approximately 760 meters. It is made up of seven district municipalities: Yaoundé I, II, III, IV, VI, and VII, and currently has a population of nearly 3 million, or 11.68% of Cameroon's total population. It is therefore a city with a high population density [7].

### 2.2. Materials and Methods

#### 2.2.1. Surveys

To assess the hygiene conditions during the sale of sachet water, we conducted a field survey in February 2020 with 30 randomly selected vendors distributed equally across the three target markets in the city of Yaoundé, *i.e.*, 10 vendors per market. The markets chosen were the Biyem assi Accacia market (Yaoundé VI), the Ekounou market (Yaoundé IV), Mokolo market (Yaoundé II). The survey was based on a

questionnaire that allowed us to draw certain conclusions on the hygiene conditions surrounding the sale of sachet water in these markets.

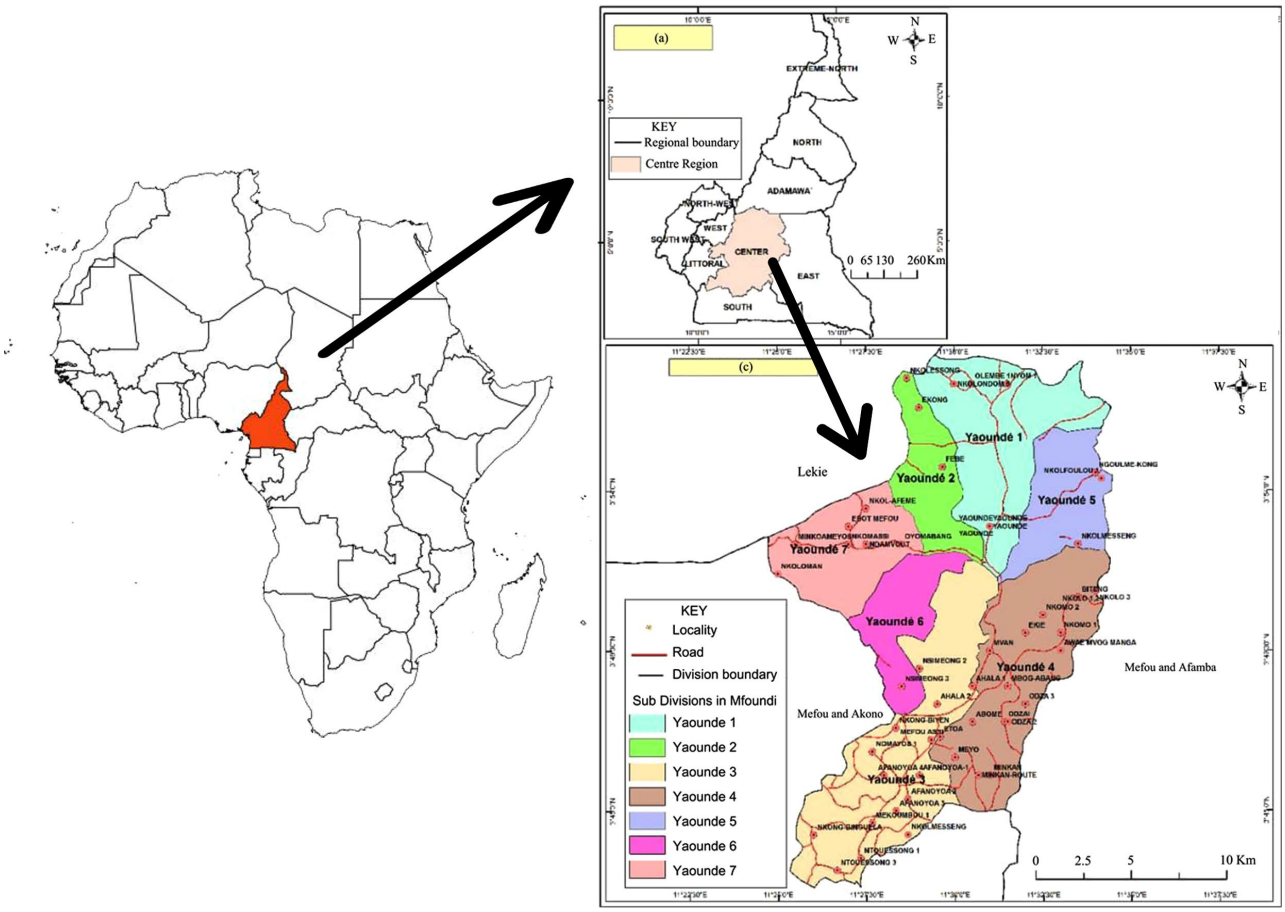


**Figure 1.** Location and administrative division of the city of Yaoundé (Source: SIG CUY).

### 2.2.2. Sampling

#### Choice of sampling and survey sites

It is important to note that despite the large number of markets in the Cameroonian capital, our choice was made on three markets (Biyem-assi, Ekounou, Mokolo) mainly because of their large capacity to accommodate traders.

#### Sample collection

The samples analyzed were water packaged in 500 ml sachets. Thus, in each market, we purchased 2 sachets of water of each brand (Omega, Golden) at 3 different points (on the road, near a trash can, in a shop). We checked that these samples were hermetically sealed, to avoid any exchange with the outside. These samples were stored in a cooler and then immediately transported to the Wastewater Research Unit of the Department of Plant Biology at the University of Yaoundé I to carry out various analyses.

#### Analytical Methods

Several experimental techniques were used. The quality of these waters was assessed by performing physicochemical and bacteriological analyses [8] [9]. The

targeted physicochemical parameters of drinking water potability were turbidity, pH, conductivity, and ammonium, calcium, magnesium, and chloride ion concentrations. Conductivity, pH, and turbidity were measured using a HANNA model HI19811-5 multimeter (pH/˚C/TDS meter). Calcium and magnesium concentrations were determined using the titrimetric method, the principle of which complies with French standard NF T 90-016. The determination of chloride and ammonium ion concentrations was carried out by the spectrophotometric method using the SPECTRODIRECT LOVIBOND spectrophotometer at the respective wavelengths of 450 nm and 630 nm. The bacteriological analysis was carried out according to ISO 9308:2014. This method consists of membrane filtration, followed by culturing in chromogenic agar and calculating the number of target organisms present in the sample. It is particularly suitable for water with a low bacterial content that will produce less than 100 total colonies on chromogenic agar for a coliform bacteria count.

## 3. Results and Discussions

### 3.1. Gender and Age of Sellers

The results obtained during the survey on the study of the sex and age of the sellers are grouped in Figure 2 and Figure 3. It emerges from the observation of Figure 2 that women are found more in this sector of activity, particularly in the Biyemassi and Ekounou markets compared to Mokolo where the opposite is noted. Overall, women are more numerous in this activity. This is due to the fact that this trade does not require significant financing. Similar observations were made by A. T. Aboli *et al.*, 2007, during the assessment of the health risk of water in plastic bags sold in the city of Abidjan. They obtained a ratio of 2:3 in favor of women [10].

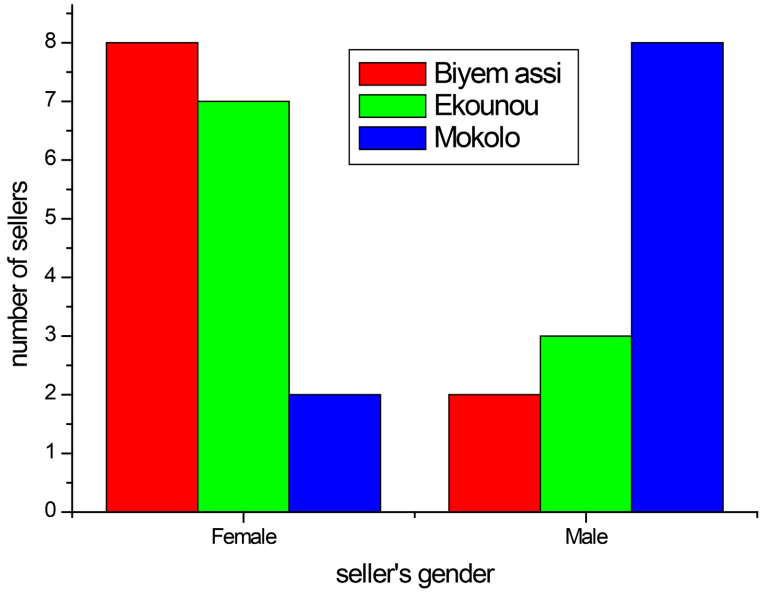


Figure 2. Distribution of sachet water sellers by gender.

Regarding the average age group of sachet water sellers (**Figure 3**)

- At the Biyem-assi market and the Ekounou market, sachet water sellers are predominantly women, mostly aged 32 - 52. This could be justified by the fact that women are more numerous in the non-agricultural informal sector and in commerce in order to be financially independent [7]. In addition, studies carried out by Simeu Kamdem *et al.*, 2023, on the anarchic installation of housing and modernization of a capital city: the case of the Ekounou and Etam-Bafia districts in Yaoundé have shown that the incomes of these populations are low [11]. This may also justify the rush of women towards this trade.
- At the Mokolo market, the vendors aged 10 - 20 are the most numerous. This market is located in the smallest district of the city of Yaoundé in terms of surface area [7], and is surrounded by several popular neighborhoods such as Briqueterie, Madagascar, Carrière, Melen. This could explain the massive presence of young boys of this age group in this market [12].

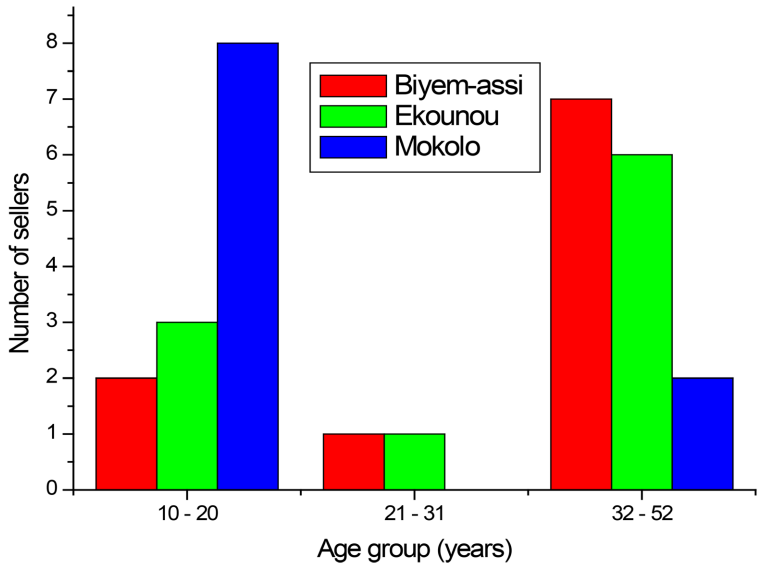


**Figure 3.** Distribution of sachet water vendors by age group.

## 3.2. Best-Selling Water Brand

A preliminary survey allowed us to identify the water brands commonly found in Yaounde markets. These are the "Omega," "Golden," and "Bonheur" brands. The results obtained when identifying the best-selling water brand are grouped in **Figure 4**. A review of this figure shows that the best-selling water brand, regardless of the market, is the "Omega" brand, followed by the "Golden" and "Bonheur" brands. According to vendors, the "Omega" brand is very affordable: a 500 mL sachet of water costs US$0.083 and a pack of 50 sachets costs US$1.49; however, for other brands, a 500 mL sachet costs US$0.083. The pack of 50 sachets costs US$1.83 for Golden and US$1.99 for Bonheur. The Omega and Golden brands seem to be popular with consumers. They are pleasant to drink, clear, and odorless. Physicochemical and bacteriological analyses will be carried out on these two brands.

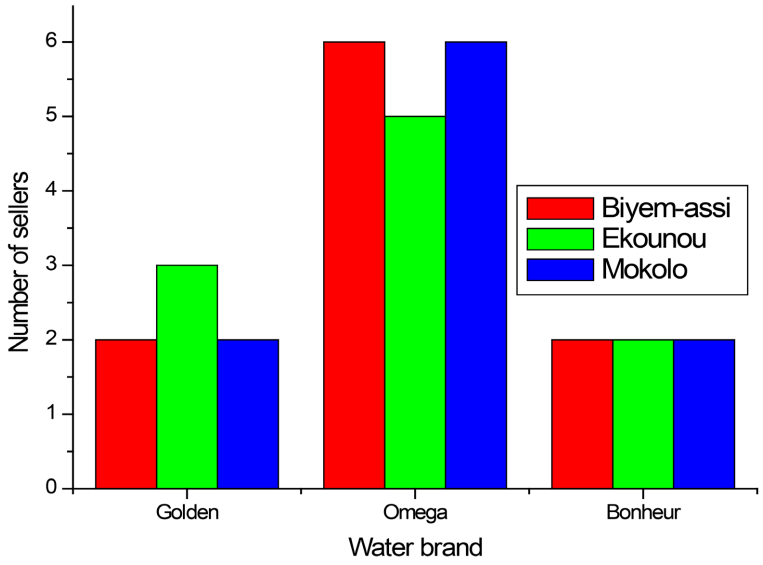


**Figure 4.** Distribution of top-selling water brands by market.

### 3.3. Plastic Bag Water Sales Environment

We explored the environment in which plastic bag water is sold. Four sales locations were considered: near a trash can, on a public road, in a shop, and near a swamp. The results are shown in **Figure 5**. An examination of this figure shows that most sachet water vendors in markets are located near trash cans. Trash cans in markets consist mainly of household waste and unsold and decomposing food. This unfortunately common practice exposes populations to several health risks. These risks are: microbiological contamination (proliferation of pathogenic germs, risk of waterborne diseases), chemical contamination (transfer of toxic substances, degradation of plastic, odors and alteration of taste), risks related to sales and handling conditions (lack of hygiene of sellers, inappropriate storage conditions). The consequences for the population are numerous. We have the increase in cases of waterborne diseases which results in increased health costs [13] [14]. We can safely say that the sale takes place in an unsanitary environment conducive to the proliferation of microbes.

### 3.4. Storage and Packaging of Water in Sachets

The sachet waters are packaged in plastic bags, this prevents any infiltration. We conducted the survey with the aim of assessing the storage conditions of the waters before and after marketing. After observation, we note that these sachet waters are stored either in the refrigerator, in a cooler, or in a bucket. The results are gathered in **Figure 6**. They show us that unsold water from the previous day's market sales is, in most cases, stored in rigid coolers for resale the next day. In these coolers, merchants generally add a little ice to serve fresh water to customers. However, the fact that these coolers are constantly open to serve sachet water to customers means that this ice melts quickly and is almost nonexistent by the end of the day. The unsold sachets are then stored in the same coolers for resale the next day. We

can conclude that the storage conditions are not suitable for hygiene regulations, as microorganisms can develop there [13].

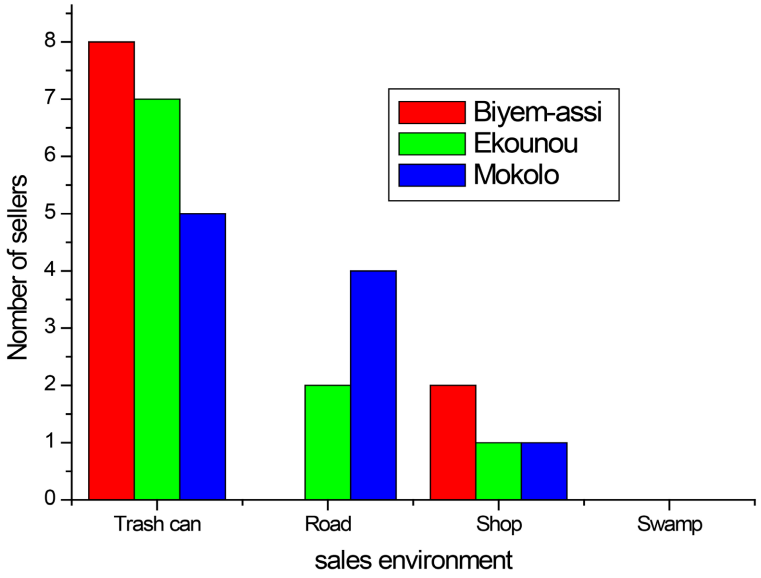


**Figure 5.** Presentation of the immediate sales environment in different markets.

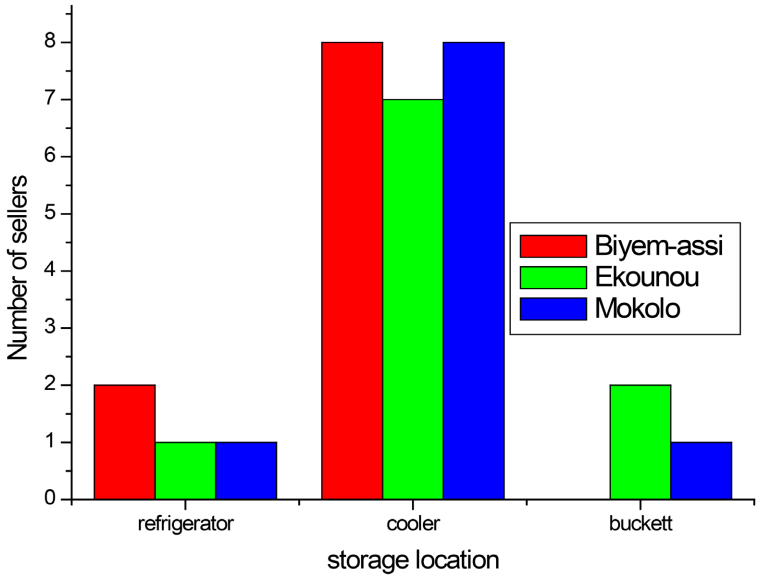


**Figure 6.** Conservation of unsold water in each market.

### 3.5. Seller's Education Level

The seller's level of education is a risk in the assimilation and mastery of good hygiene practice rules. It can influence the way water bags are stored. It was assessed using a questionnaire. These observations are summarized in **Figure 7**. This analysis shows that the majority of vendors surveyed at the Ekounou market and the Biyemassi market did not attend formal schooling. On the other hand, those in the Mokolo market mostly have a primary school education. This could explain

the lack of hygiene around these products. A good understanding of hygiene rules sometimes depends on the educational level [15].

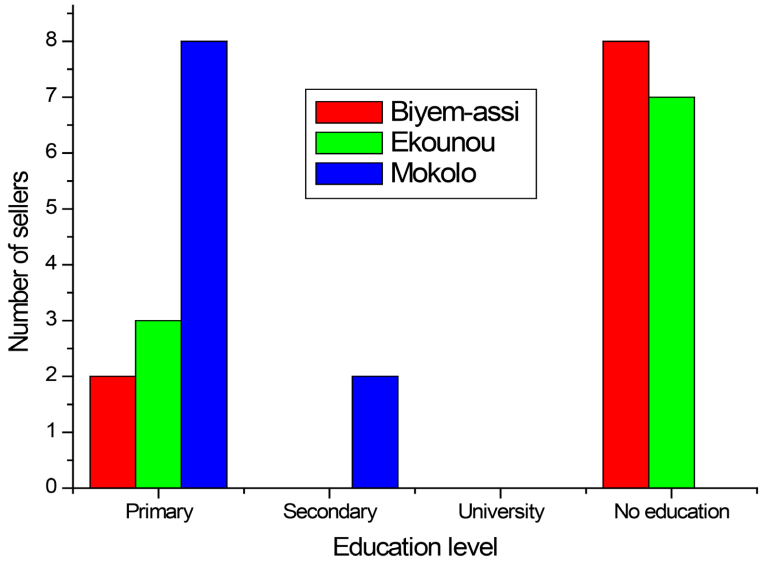


**Figure 7.** Distribution of sachet water vendors by education level.

In order to assess the quality of the water contained in the sachets, physicochemical and bacteriological analyses were carried out on the Omega and Golden water sachets. Because these two waters are the most consumed and most appreciated by consumers. Regarding the determination of some physicochemical parameters of the water samples, the results are recorded in **Table 1**.

**Table 1.** Values of physicochemical parameters.

| Samples parameters | Golden | Omega | WHO standard | Cameroon standard |
|---|---|---|---|---|
| **pH** | 7.23 ± 0.01 | 6.99 ± 0.01 | 6.50 - 8.50 | 6.50 - 9.00 |
| **Conductivity (µS·cm$^{-1}$)** | 350 ± 0.02 | 400 ± 0.02 | ≤400 | - |
| **Turbidity (UTN)** | 0.00 ± 0.02 | 0.00 ± 0.02 | | ≤ 2 |

It emerges from the analysis of **Table 1** that:

The pH measured for our samples is 7.23 for Golden and 6.99 for Omega. These two values comply with the Cameroonian standard (6.5 - 9) and the WHO standard (6.5 - 8.5). Therefore, these waters comply with the standards, unlike the sachet water sold in Lomé, Togo [16]. The conductivity is 400 µS·cm$^{-1}$ for Omega brand water and 350 µS·cm$^{-1}$ for Golden brand water. These two values comply with the WHO standard for conductivity (≤400 µS·cm$^{-1}$). Unlike the water in plastic bags sold in Lomé, Togo, which has a very low conductivity of between 19.1 and 174 µS·cm$^{-1}$ [16], we can therefore conclude that these two brands of water

are suitable for consumption for the conductivity parameter. The turbidity values show that the water in these samples is perfectly clear. The results are similar to those obtained in water packaged in plastic bags in Atakpamé [17]. The ammonium, calcium, magnesium and chloride ion contents are recorded in **Table 2**.

**Table 2.** Cation and anion contents of water.

| Parameters ($mg{\cdot}L^{-1}$) | Golden | Omega | WHO standard | Cameroon standard |
|---|---|---|---|---|
| **Calcium ($Ca^{2+}$)** | 0 | 0.02 | ≤100 | ≤100 |
| **Magnésium ($Mg^{2+}$)** | 0.55 | 0.41 | ≤50 | ≤50 |
| **Chlorures ($Cl^{-}$)** | 0.07 | 0.01 | ≤200 | ≤200 |
| **Ammonium ( $NH_4^+$ )** | 0.04 | 0.21 | ≤0.5 | |

Analysis of this table shows that calcium ions are absent in the Golden sample and in trace amounts in the Omega sample. This is contrary to the information on the plastic packaging, which states 0.8 $mg{\cdot}L^{-1}$ for Golden and 0.7 $mag{\cdot}L^{-1}$ for Omega. The magnesium levels in both brands are below Cameroonian and WHO standards. This difference could be due to the accuracy of titrimetry for calcium and magnesium. The limiting factors of this method are: endpoint detection, indicator quality, ionic interferences, solution pH, titrant concentration (EDTA), handling errors, detection limits. It would have been wise to use other techniques such as atomic absorption spectrophotometry or inductively coupled plasma atomic emission spectrometry which offer lower detection limits. This would allow us to confirm this difference. These waters can be classified as freshwater. Furthermore, to compensate for the magnesium deficiency, it is necessary to consume foods rich in magnesium (cereals, legumes, potatoes, bananas, snails, etc.) because they are enzyme activators and promote sleep. Regarding calcium, one could compensate for the deficiency by consuming dairy products, green vegetables and fruits because calcium helps prevent osteoporosis [18]. The chloride ion contents obtained are: 0.07 $mg{\cdot}L^{-1}$ for golden and 0.01 $mg{\cdot}L^{-1}$ for Omega.

These values are different from those listed on the packaging of the sample bags. They are respectively 2.8 $mg{\cdot}L^{-1}$ for Omega and 2.7 $mg{\cdot}L^{-1}$ for golden. These measured values are much lower than those recommended by the WHO and the Cameroonian standard (≤200 $mg{\cdot}L^{-1}$). These waters would therefore be fit for human consumption. It should be noted that the presence of chloride ions in these waters could show that they are treated with chlorine. Regarding ammonium ions, the levels obtained in our samples are 0.04 $mg{\cdot}L^{-1}$ for golden and 0.21 $mg{\cdot}L^{-1}$ for Omega. The ammonium ion content in the Omega sample is higher than in the golden sample. These values are lower than the Cameroonian standard (≤0.5 $mg{\cdot}L^{-1}$). Indeed, water rich in ammonium degrades the quality of the water and constitutes an indicator of pollution.

### 3.6. Results of the Bacteriological Analysis

Bacteriological analysis was performed using the membrane filtration method.

The results of this analysis are shown in Table 3.

Table 3. Results of the bacteriological analysis.

| Samples parameters | Golden | Omega | WHO standards |
|---|---|---|---|
| **Fecal coliforms** | 0 | 0 | 0 |
| **Fecal streptococcus** | 0 | 0 | 0 |

This table reveals a total absence of fecal coliforms and fecal streptococci.

These results are consistent with the WHO standard. This is in contrast to studies conducted on sachet water production units in the cities of Kara and Okodé [19], and on industrial mineral waters sold in plastic bags in the city of Conakry which in most cases contain fecal streptococci and fecal coliforms [20]. These waters are therefore bacteriologically sound, as water suitable for human consumption should be characterized by a total absence of fecal coliforms and fecal streptococci.

## 4. Conclusion

Ultimately, this study aimed to assess the health risks of sachet water consumed in the city of Yaoundé, Cameroon. To do this, we focused on two brands of sachet water, namely Golden and Omega. These are the most widely consumed brands. We used various methods to analyze them, including potentiometry, volumetry, colorimetry, and membrane filtration. Based on the results obtained, it appears that the values indicated on the packaging are not actually those obtained in the laboratory. Nevertheless, these values generally meet the standards recommended by the WHO and Cameroon. From a bacteriological perspective, these waters are free of fecal streptococci and fecal coliforms: they are therefore bacteriologically healthy. Except for the calcium and magnesium levels, which are low despite their vital importance for the body. It is crucial to raise awareness among the population about the risks of bad practices and to put in place adequate regulations and infrastructure to ensure the sale and storage of water in plastic bags under appropriate hygienic conditions.

## Acknowledgements

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## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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