IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 15, Issue 8 Ser. I (August 2021), PP 07-15
www.iosrjournals.org

Physico-chemical Quality of Conditioned Water Sold in the Urban Areas: A case Study of the City of Niamey (Niger)

MIJITABA SAHIROU Bachir, LAOUALI Mahaman Sani, AYOUBA MAHAMANEAbdoulkadri, ADAMOU HASSANEHassane, SOULEY KALLOMoutari, AMADOUHaoua,MANZOLAAbdou Salam
(*Laboratory Materials-Waters-Environment/ Faculty of Sciences and Technology/ Departement of Chemistry / Abdou Moumouni University of Niamey, Niger)*
P. O. Box 10662, Niamey, Niger

Abstract
The consumption of conditioned water has significantly increased in urban centers over the last decades. However, studies on the quality of all imported and local conditioned water are very rare in Niamey (Niger). To protect the consumer, this study examines the physico-chemical quality of 20 brands of bottled water and 6 brands of plastic sachet water. The assessment on the physicochemical parameters was carried out by molecular absorption spectrophotometry and titrimetry. The results obtained showed that the content on calcium, magnesium, sulphate, bicarbonates, chlorides, nitrates and nitrites are within WHO standards. An abnormal content of 61.77 mg.L^{-1} of nitrate ions in a sachet water sample and an acidic pH of 2.62; 3.31; 5.14 on the supplemented water were observed. Therefore, the majorityof bottled water can be consumed without danger. Hard and highly mineralized natural mineral water as well as supplemented water are not suitable for exclusive consumption. One of sixbrands of sachet water does not respond to human consumption and three of six does not respond to reconstitution of baby bottles. Therefore, the study establishes an overview of the physicochemical characteristics of the packaged water marketed in Niamey.

Keywords*: Conditioned waters, physicochemical quality, urban area, Niamey.*

HIGHLIGHTS

- *The physico-chemical analyzes provide an overview of the physico-chemical characteristics of conditioned water*
- *Hard and highly mineralized natural mineral water and the supplemented water cannot be used for exclusive consumption.*
- *Bottled water sold in Niamey is the most consistent with WHO guideline values compared to sachet water.*
- *50% of sachet water analyzed produced in Niamey are not suitable for reconstitution of baby bottles.*

Date of Submission: 26-07-2021 Date of Acceptance: 11-08-2021

I. Introduction

Covering about 71% of the earth's surface, water is the most abundant natural resource on earth and also one of the essential vital resources to man [1-4]. Access to drinking water is a fundamental right. It is used for food, personal hygiene or leisure purposes [5].

Although it is available in sufficient quantity, accessibility to safe drinking water remains a daily struggle. Indeed, 29% of the world's population, or 2.1 billion people, do not have safely managed drinking water services. In sub-Saharan Africa, only 41% of the population use an uncontaminated water source and only 24% use safely managed water sources[6].

In West Africa, like Niger, access to drinking water is one of the daily concerns of the populations. Access rates need to be improved. In rural Niger, 41.3% of households use water from an improved source (tap in housing/concession, public tap water, pump/borehole, protected dug well, protected water source, rain water and bottled water) and in urban areas, the proportion was 91.2% in 2015[7].

In urban centers the supply of safe and drinkable water is still insufficient. Groundwater and spring water can only serve a small part of communities. Most often, the wells are shallow and located near sources of pollution and the water quality is rather poor[8-10]. The absence or failure of a drinking water distribution network, mistrust of tap water, or for reasons of convenience, and the population resorts to other types of commercialized drinking water including those packaged in a bottle or plastic bag [11].To be eligible for human consumption, these different types of water must meet the physicochemical and microbiological quality

standards established by the World Health Organization through the guide values applicable to all water intended for human consumption with the exception of natural mineral water and medicinal waters [12-16].

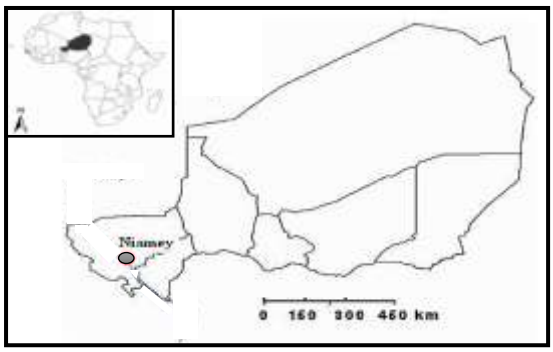
In this sense, several studies have been carried out on a recurring basis throughout the world in the sense of protecting consumers[13, 14, 17-19]. In the West African sub-region, some studies reveal an excellent or still acceptable physicochemical quality of commercialized bottled water in Burkina Faso and Nigeriawhile other studies in Nigeria report violations of international quality standards for packaged water[2-4, 20, 21]. These studies show that the drinkability limits are exceeded for certain metallic trace elements.

In Niger, several studies have mainly studied the physicochemical and/or bacteriological qualities of groundwater and surface water without mentioning the quality of conditioned water[8, 22, 23]. Recently, some works have started to take into account the quality of water packaged and sold in Niamey. This is how researches have emerged on the historical, socio-economic and cultural aspects of the sale of packaged water in Niamey[11]. In addition, the study carried out by Mijitaba Sahirou and his collaboratorslike those carried out in the sub-region, shows that the sachet watershaving no traceability and sold everywhere in Niamey are unfit to human consumption [24]. The consumption of this packaged water is growing and scientific publications are lacking to document the quality of all types (in bottles or sachets) of imported packaged water and those produced locally in Niger, particularly in Niamey. This study focused on the study of the physicochemical quality of packaged water commercialized in the city of Niamey and the comparison of the results with WHO guideline values in order to protect consumers and facilitate their choice.

II. Materials And Methods

2.1. Study area and Sampling

Niamey is the capital of the Republic of Niger. Located in the southwest of Niger between latitudes 13°35 'and 13°24' South and longitudes 2°15 'East, Niamey is an urban city and includes five communal districts. Its population is estimated at 1,243,453 inhabitants over an area of 255 km^2[22, 23, 25]. For several years, this population has gradually taken the habit to consuming packaged water.



Figureno 1: location of Niamey

The sampling campaign took place from September 10 to 24, 2019 in the city of Niamey. Two places were favored for the collection of samples: supermarkets and shops. Only packaged waters with traceability were studied. The samples thus collected, a total of twenty-six (twenty in bottles and six in sachets) were labeled, stored at a temperature of 4 ^{0}C and then transported in coolers to the laboratory for analysis.
A stock-taking of the different types of packaged water sold in the city of Niamey was carried out. Then followed that of manufacturers as well as the countries of origin of these packaged water.

2.2. Physico-chemical analyzes

The pH and the electrical conductivity (EC) were measured by using a WTW 3434 multimeter. The chemical analyzes were carried out by using a UV-Visible Evolution 300 spectrophotometer according to spectrophotometric methods for NO_3^-, NO_2^- ions and according to the nephelometric method for SO_4^{2-} ions.
Chloride (Cl^-), calcium (Ca^{2+}), magnesium (Mg^{2+}) ions as well as bicarbonates (HCO_3^-) are determined by the titrimetric methods described by Rodier and his collaborators [26].

III. Results

3.1. Stocktaking of packaged water sold in the city of Niamey

Two types of packaged water commercialized in the city of Niamey were inventoried: bottled water and sachet water. Bottled water is sold in supermarkets and / or shops and sachet water exclusively in shops. Part of the packaged water comes from local production (Niger) and the other part comes from neighboring countries of Niger (Burkina Faso and Benin) and France.

3.1.1. Local production

Two types of packaged water produced locally are commercialized in Niamey: water packaged in bottles and water packaged in plastic bags commonly called "pure water".

During this study, five bottled waters produced in Niger and commercialized in Niamey are presented in Figure 2.

Figure no 2: Bottled water from Niger and commercialized in Niamey

"Pure water" (sachet water) is widely consumed by the population because of the accessibility and low cost compared to bottled water. Six brands of pure water identified are showed in figure 3.

Figure no 3: pure water with a fixed brand marketed in Niamey

3.1.2. Foreign production

Figure 4 illustrates bottled water imported from the sub-region mainly from Benin (POSSOTOME, COMPTESSE DES FRUITS and KUWABO) and Burkina Faso (LAFI, YILMA, JIRMA and LA FONTAINE). The four brands of bottled water imported from Burkina Faso are natural mineral waters as indicated on their labels.Waters from Benin include one brand of thermal water and two brands of supplemented water (enhanced with lemon juice and other fruits).

Figure no 4: Bottled water imported from Benin and Burkina Faso

In addition, among the imported waters, ten (10) brands come from France in which five are natural mineral waters and one brand of spring water, CRISTALINE (Figure 5).

Figure no 5: natural mineral water and spring water imported from France

Figure 6 shows naturally carbonated natural mineral waters (VICHY CELESTIN,VICHY St YORRE and FAUSTINE) and a carbonated natural mineral water (PERRIER) imported from France.

Figure no 6: naturally carbonated natural mineral waters and the carbonated natural mineral water imported from France

3.2. Names of stocked water

The WHO guidelines recommend the following names for natural mineral water as appropriate: natural mineral water, naturally carbonated natural mineral water and carbonated natural mineral water. However, the following names can be read on the labels of bottled water produced in Niger commercialized in Niamey: "Drinking water" for the REGAL brand, "Natural water" for the C'EST BON brand or "natural mineral water" for the BELVIE, DALLOL and TELWA brands. Any packaged water referred to as natural mineral should be packaged while preserving its original quality without any treatment or addition of any substance; any treatment modifying the mineral matrix is prohibited[6]. But, it is possible to remove unwanted natural elements such as arsenic, radon, etc. For sachet water, the names "spring water" for the MALAIKA brand, "table water" for the ZAMZAM, YARD and AMICO brands, "pure water" for the HASSAO brand, "mineral water" for the ALIYA brand are used. Each of the four brands of bottled water from Burkina Faso is referred to as "natural mineral water".

The overview on the naming of the stocked water showed that the bottled water from Burkina Faso as well as three brands of bottled water from Niger are referred to as natural minerals. Indeed, a natural mineral water must be of original purity, untreated, have a constant characteristic composition, its temperature must be constant at emergence. It must also be bacteriologically safe and be recognized as a mineral in the country of origin. Natural mineral water is therefore distinguished from other types of water intended for human drinking by its natural content of trace elements and its original purity[17].

The POSSOTOME brand from Benin is sparkling water and is called "carbonated thermal mineral water" while the COMTESSE DE FRUITSand KUWABO brands are supplemented waters. No sparkling water produced in Niger was found at the market during the stocktaking. Naturally sparkling natural mineral waters are natural mineral water that undergo carbon dioxide (CO_2) enrichment from the same source as water or from another natural source [17]. This type of water comes mainly from France. Finally, natural mineral water with the addition of carbon dioxide are natural mineral water reinforced with carbon dioxide that does not come from a natural source. This is the case with the PERRIER brand (France).

3.3. Physico-chemical quality of packaged water sold in Niamey

The results of the physico-chemical analysis of the studied waters are presented in Table 1.

Bottled water produced in Niger has a pH within the WHO standard between 6.5 and 8.5 with the exception of a brand of water whose pH of 5.94 tends to be acidic. This water is weakly mineralized with electrical conductivity values ranging between 8.9 and 210 µScm^{-1}. The calcium and magnesium contents found in this water is well below the potability limit values of 100 mg.L^{-1} and 30 mg.L^{-1} respectively. The total hardness varie from 0.3 to 5.4 french degrees (°f) (1°f corresponds to 10 mg.L^{-1} of $CaCO_3$). The contents of sulphate, bicarbonate and chloride anions are also low and vary respectively from 0.00 to 24.35 mg.L^{-1}, from 2.44 to 39.95 mg.L^{-1} and from 7.98 to 15, 97 mg.L^{-1}. Nitrates are present at concentrations varying from 0.56 to 11.60 mg.L^{-1}.

Results from six brands of pure water show pH values that meet WHO guideline values except for one brand of pure water with a pH of 6.39. Electrical conductivity (EC) ranges from 52.6 to 545 µScm^{-1}. The total hardness of these pure water samples ranges from 0.6 to 25.2 °f. These waters are thus divided into fresh waters (TH <15 °f), hard waters (15 <TH <30 °f) and very hard waters (TH> 30 °f). There are soft waters such as ZAMZAM, ALIYA, HASSAO, MALAIKA, YARD whose hardness is less than 15 °f (150 mg.L^{-1} of $CaCO_3$) and a hard water brand, AMICO, whose hardness is 25.2 °f is greater than 15 °f. The nitrate contents oscillate between 0.09 and 61.77 mg.L^{-1}. One of these samples, ALIYA, showed a high nitrate level of 61.77 mg.L^{-1} exceeding the WHO guideline value of 50 mg.L^{-1}.

The results of physico-chemical analysis of packaged water imported from Benin and Burkina Faso show that the COMTESSE DE FRUITS (pH 2.62), KUWABO (pH 3.31), POSSOTOME (pH 5.14), JIRMA (pH 6.18) and LAFI (pH 6.24) brands have pH values less than 6.5. The LA FONTAINE and YILMA brands have their pH between 6.5 and 8.5 which is recommended by the WHO. The electrical conductivity of this imported water varies from 9.3 to 945 µS.cm^{-1} for the bottled water imported from Burkina Faso. The JIRMA brands is very weakly mineralized (CE = 9.3 µS.cm^{-1}). The LAFONTAINE and YILMA brands are moderately mineralized waters (200 < CE < 400 µS.cm^{-1}). For the supplemented water from Benin the electrical conductivity varies from 369 to 945 µS.cm^{-1}.The calcium and magnesium content are below their limit values of 100 mg.L^{-1} and 30 mg.L^{-1} respectively.

Tableno 1:Physico-chemical parameters of conditioned waters sold in Niamey

Samples	pH	CE (µS.cm^{-1})	Cl^- (mg.L^{-1})	HCO_3^- (mg.L^{-1})	Ca^{2+} (mg.L^{-1})	Mg^{2+} (mg.L^{-1})	Total hardness (°f)	NO_3^- (mg.L^{-1})	NO_2^- (µg.L^{-1})	SO_4^{2-} (mg.L^{-1})
Bottle water produced in Niger										
BELVIE	7.4	210	15.97	39.95	10.42	6.8	54	11.60	5.96	24.35
DALLOL	6.53	46.5	14.2	7.16	0.8	0.48	0.4	10.45	ND	2.83
TELWA	7.39	152.7	12.42	45.14	0.8	0.72	0.5	0.56	ND	3.06
C'EST BON	5.94	8.9	14.2	2.44	0.8	0.24	0.3	1.67	ND	0.00
REGAL	7.59	17.3	7.98	5.49	0.8	0.85	0.55	1.51	ND	0.00
sachet water (*pure water*) of Niger										
ZAMZAM	6.39	145.7	10.65	5.795	1.60	0.72	0.7	2.18	40.75	30.31
HASSAO	7.25	144	7.1	22.57	12.02	4.61	4.9	27.36	88.46	4.44
MALAIKA	7.95	52.6	7.1	2.44	1.20	0.72	0.6	17.96	26.83	1.46
ALIYA	7.32	174.1	14.2	3.66	9.21	5.83	4.75	61.77	120.26	5.12
AMICO	7.91	545	12.42	92.72	39.27	37.43	25.2	7.42	8.94	128.66
YARD	7.64	68	7.1	3.66	4.8	1.94	2.00	0.09	ND	20.00
Bottle waterimported from Benin and Burkina Faso										
LA FONTAINE	6.62	232	13.31	69.99	19.23	11.18	9.4	2.11	ND	1.23
JIRMA	6.18	9.3	10.65	3.66	0.4	0.24	0.2	0.14	ND	1.00
YILMA	7.36	286	11.53	97.6	25.65	13.12	11.8	4.93	ND	2.38
LAFI	6.24	28.3	14.2	4.27	2.40	0.97	4.00	0.53	ND	1.23
POSSOTOME	5.14	761	26.62	128.1	55.71	15.80	20.40	0.09	ND	4.44
KUWABO	3.31	369	21.3	ND	4.00	1.94	7.20	36.45	4.47	5.12
COMTESSE DE FRUITS	2.62	945	177.5	ND	ND	ND	ND	1.05	ND	0.32
Bottle water imported from France										
CRISTALINE	7.34	454	20.41	115.9	85.37	2.67	22.4	0.23	ND	28.38
EVIAN	7.61	613	17.75	101.41	67.33	37.92	32.4	3.66	ND	16.57
VOLVIC	7.72	216	22.18	37.82	13.62	7.77	6.6	6.75	ND	9.70
CONTREX	7.42	2360	20.41	216.55	480.96	92.37	158	2.98	ND	1750.91

HEPAR	7.39	2640	25.73	215.02	501	116.68	173	4.01	ND	184.98
VICHY CELESTINS	6.3	4810	301.75	1634.8	88.17	12.15	27	1.35	ND	162.14
VICHY S^t YORRE	6.63	6950	408.25	2385.1	76.15	17.01	26	1.88	ND	294.87
VITEL	7.53	1302	14.2	222.65	228.45	46.18	76	4.22	ND	784.79

ND : not detected

The imported water from Benin and Burkina Faso present two hydrotimetric qualities. These are mainly soft waters(total hardness less than 15 °f) and a brand of hard water, POSSOTOME (total hardness of 22.40 °f). The contents of sulphates and chlorides are also low. On the other hand, the COMTESSE DE FRUITS brand has a high content of chloride ions (177.5 mg.L^{-1}). But the presence of chlorides in drinking water is less worrying for health compared to its acceptability because of its characteristic salty taste which manifests itself when the concentration of chloride ions exceeds 200 mg.L^{-1}[6]. Thus a high chloride content can then lead the population to resort to water having a more neutral taste.

Imported water from France has its pH between 6.5 and 8.5 except for the VICHY CELESTINS brand (naturally carbonated natural mineral water) whose pH is 6.3. Overall, this water is highly mineralized because the lowest electrical conductivity value obtained is 210 µS.cm^{-1}. The total hardness of this water varies from 6.6 to 173 french degrees (°f). These hardness values imply very variable contents of calcium and magnesium ions. The contents of calcium ions vary from 2.67 to 501 mg.L^{-1} and those of magnesium ions vary from 6.67 to 116.68 mg.L^{-1}. Similar levels of calcium and magnesium ions were published by Some and his collaborators during a similar study on the same brands of water marketed in Burkina Faso [20]. The nitrate ions contents varying from 0.23 to 6.75 mg.L^{-1} are much lower than the maximum value of 50 mg.L^{-1}. The nitrite ions contents are very low and have not been detected. The contents of sulphate ions oscillate between 9.70 and 1750.91 mg.L^{-1}. Analysis of these results shows the existence of sulphated water. Thus the CONTREX, VICHY S^t YORRE and VITEL brands have contents greater than 200 mg.L^{-1} which are respectively 1750.91; 294.87 and 784.79 mg.L^{-1}. The chloride ions contents for the VICHY CELESTINS and VICHY S^t YORRE brands exceed 250 mg.L^{-1} which is the WHO guideline for spring water. It should be noted that the brand of spring water, CRISTALINE, listed among the water imported from France complies with the WHO guidelines concerning the parameters measured.

IV. Discussion

The results of physicochemical analysis reveal that the bottled water produced in Niger and marketed in Niamey is fresh water because the total hardness varies from 0.3 to 5.4 °f, therefore less than 15 °f. This low value of hardness may be due to the nature of the soils crossed by the water or to the use of filters which could retain certain major elements such as Ca^{2+}, Mg^{2+}, HCO_3^- ions etc. [27]. According to the WHO there is not sufficient scientific information on the benefits and dangers of consuming very poorly mineralized water over a long period to be able to make recommendations. Nevertheless, the ingestion of fresh water could cause health risks because of their power to dissolve harmful compounds such as cadmium, mercury, lead, particularly on the cardiovascular level[6, 13].

Some of the pure water samples analyzed are weakly mineralized and others are moderately mineralized. The results also show low levels of calcium and magnesium compared to the limit values for all the sachet water analyzed. A hydrotimetric quality similar to that of sachet water from Niger commercialized in Niamey was reported during a study on sachet water sold in Kano State in Nigeria [3]. Sulphate and chloride ions are in small quantities in these pure water unlike nitrate and nitrite ions which are in significant quantities. In water, nitrates are present by leaching nitrogen products into the soil, by decomposing organic matter or fertilizers [5]. One of the six samples of sachet water sold in Niamey has a nitrate ion content exceeding the limit of 50 mg.L^{-1}. This exceeding of the limit is a concern for health because the nitrate ions in abnormal content, in the human organism, can be transformed into nitrite ions and could, in children mainly, cause methemoglobinemia which is an inability of the blood to oxygen transport. Nitrates can also lead to the formation of carcinogenic and mutagenic nitrosamines in humans when combined with amines[5, 13].

Unlike bottled water from Niger with similar physicochemical qualities (EC, pH, NO_3^-), bottled water from Benin and Burkina Faso has very varied physicochemical characteristics. The degree of mineralization, the hydrotimetric quality as well as the pH vary widely from one brand of water to another. The variation in these parameters would be linked to the nature of the land crossed by the water and to the potential treatments that this water underwent before bottling, particularly in the case of lemon water. The conductivity of this water varies from 232 to 945 µS.cm^{-1}, except for the very weakly mineralized JIRMA brand (CE 9.3 µS.cm^{-1}). They are, in general, more mineralized than bottled water produced in Niger, whose highest conductivity is 210 µS.cm^{-1}. But, they are less mineralized than the CONTREX, HEPAR, VITEL, VICHY CELESTIN and VICHY S^t-YORRE brands from France. The nitrate ions contents are similar (NO_3^-<7 mg.L^{-1}) in all bottled water analyzed apart

from the BELVIE and DALLOL brands (produced in Niger) in which the nitrate concentration exceeds 10 $mg.L^{-1}$.

The VICHY CELESTIN (pH 6.3) and VICHY S^t-YORRE (pH 6.63) brands of naturally carbonated natural mineral water imported from France attest to acidic pH. This is because carbonated water tend to be acidic due to their carbon dioxide content which contributes to lowering the pH. In addition, water with an acidic pH and weakly mineralized can be aggressive and corrosive[6, 20]. Here, on the other hand, these bottled water brands with the lowest pH are the most mineralized with respectively conductivity values of 4810 and 6950 $\mu S.cm^{-1}$. The COMPTESSE DE FRUITS and KUWABO brands from Benin aresupplemented water. They differ from other types of water sold in Niamey by their acidic pH, low calcium and magnesium content coupled with high values of the electrical conductivity. Indeed, some supplemented waters are produced on the basis of natural mineral water or spring water enriched with carbohydrates or calcium and magnesium, others are flavored, most often sweetened. The COMPTESSE DE FRUITS and KUWABO brands are supplemented with lemon juice and other fruits, which could explain its acidic pH of 2.62 and 3.31 respectively and moreover the high conductivity of these waters.

4.1. Difference in quality between sachet water and bottled water produced in Niger

Bottled waters from Niger sold in Niamey are less mineralized (average conductivity 87.08 $\mu S.cm^{-1}$) than sachet waters (average conductivity 188.23 $\mu S.cm^{-1}$); calcium and magnesium ions are in very low amounts. However, like sachet water, some bottled water brands have their source either in Niamey, this is the case of the BELVIE brand, or nearby to Niamey, as is the case of the TELWA brand produced in Kouré, a village located about 58 kilometers from the Niamey. In addition to the nature of the land crossed by the water, the difference in the depth of the cloth, a specific treatment such as filtration or ions exchange could explain this difference in the content of major elements between bottled water and sachet water. In addition, nitrate and nitrite ions concentrations are higher in sachet water (NO_3^-: 0.09 - 61.77 $mg.L^{-1}$) than in bottled water (NO_3^-: 0.56 - 11.60 $mg.L^{-1}$). This difference can be explained by the depth of the cloth captured or by the proximity to the sources of contamination[28, 29]. A superficialgroundwater is, in fact, subject to contamination of the water resource due to human activities, in particular the excessive use of chemical fertilizers for gardening cultivated in the city of Niamey, on the banks of the Niger River. The similarity of the physicochemical characteristics of bottled water from Niger sold in Niamey and the difference in the content of certain parameters between the sachet and the bottled water show that either these bottled water cross land with similar characteristics, or they were subjected to treatments aimed at eliminating certain substances (Ca^{2+}, Mg^{2+}, NO_3^-, NO_2^-, SO_4^{2-}…) or correcting their concentrations. This would not be the case for sachet water, the physicochemical characteristics of which are more variable.

4.2. Advantage and disadvantage: which type of water to choose?

An essential component, water plays an important role in the transport and elimination of waste in the human body. Taking into account the natural chemical composition of water, human activities that can generate contamination of water resources, all spring water must have major element and trace element content in accordance with the guideline values of the WHO or country standards. To be safe for human consumption, drinking water should not contain toxic substances at concentrations that could compromise the health of the consumer throughout his life, however, must contain substances useful at certain concentrations for the proper functioning of the human organism. Some brands of bottled imported water from France such as VITEL, HEPAR, CONTREX have significantly higher calcium and / or magnesium ion contents than the concentrations normally accepted for spring water. These types of water are generally accepted because they are considered food rather than drinking water as such. They should not then be considered drinkable for exclusive consumption because some of them contain quantities of ions such that they should be contraindicated in lithiasis patients, for example. In addition, they would be beneficial for women after childbirth or for postmenopausal women and for good growth of infants [13, 15]. In addition, for a pregnant woman, the need for calcium and magnesium increases especially at the end of the third trimester of pregnancy and during breastfeeding. Thus the contribution of these elements must be reinforced during these periods. In this sense, many spring or mineral waters rich in calcium and magnesium may be suitable according to Gay and Hartemannin 2014 [17]. In addition, this water can also be used for children who have difficulty in taking milk products or who don't like them. Because the calcium in natural mineral water rich in calcium and magnesium has a bioavailability similar to that of calcium in milk. However, for infants the water to be used for reconstitution of baby bottles must meet additional conditions compared to water intended for human consumption. It must be weakly mineralized, non-effervescent, low in fluorine and must not contain nitrate ions at more than 15 $mg.L^{-1}$[17]. Unlike supplemented waters with acidic pH, all bottled waters analyzed from Niger and those from Burkina Faso may be suitable for reconstitution of baby bottles given their low mineralization and low nitrate ion content. Moreover little mineralized natural mineral water such as VOLVIC and EVIAN are

recommended for reconstitution of baby bottles in France[17]. But 50% of sachet water analyzed produced in Niamey for which the nitrate content is greater than 15 $mg.L^{-1}$ are not suitable forreconstitution of baby bottles.

Acknowledgmemt

The autors deeply acknowlege the Laboratoire-Matériaux-Eaux-Environnement (Materials-water-Environmental laboratory) of the faculty of Science and technology of the Abdou Moumouni University in Niamey, where the physico-chemical analyzes were carried out.

V. Conclusion

The results obtained showed that the conditioned water produced in Niger commercialized in Niamey and that imported from Benin and Burkina Faso are fresh waters. These waters are weakly mineralized and poor in calcium, magnesium, sulphate anions, chlorides, bicarbonates and nitrites. The nitrate contents are well below the limit value of 50 $mg.L^{-1}$ for bottled water and for 83.33% of brands of sachet water. Imported bottled water from France are essentially hard and highly mineralized waters. According to this study, no violation of the acceptability limit was observed for bottled water from Niger and those imported from Burkina Fasoexcept a slight decrease in pH for some brands of water.However, supplemented watersfrom Benin have an acidic pH. An abnormal nitrate content was observed in a plastic bagged water sample. Natural mineral water, for their part, are not subject to a limitation of the contents concerning the measured parameters. In perspective, studies including the search for certain substances likely to pass from the container to the content, as well as the associated health risks, would also be relevant.

References

[1]. Ojo OA, Bakare SB, and Babatunde AO. Microbial and chemical analysis of potable water in public-water supply within LagosUniversity, Ojo. *African Journal of Infectious Diseases*. 2005; 1(1): 30-35. Doi : 10.4314/ajid.v1i1.42083.

[2]. Mbaeyi-Nwaoha, I. E. & Egbuche, N. I. Microbiological evaluation of sachet water and street-vended yoghurt and "Zobo" drinks sold in Nsukka metropolis. *Int. J. Biol. Chem. Sci.* 2012; 6(4): 1703-1717. http://dx.doi.org/10.4314/ijbcs.v6i4.27.

[3]. Sheshe, M. U., Magashi. Assessment of physicochemical quality of sachet water produced in selected local Government areas of Kano metropolis, Kano State-Nigeria. *Bayero Journal of Pure and Applied Sciences*. 2014; 7(2): 31-35. https://doi:10.4314/bajopas.v7i2.7.

[4]. Yusuf, Y. O., Jimoh, A. I., Onaolapo, E. O. & Dabo, Y. An assessment of sachet water quality in Zaria Area of Kaduna State, Nigeria. *Journal of Geography and Regional Planning*. 2015; 8(7): 174-180. doi: 10.5897/JGRP2015.0501.

[5]. Toure, A., Wenbiao, D., Keita, Z., Dembele, A., and Elsamoal Elzak Abdalla Elzaki, E. E. A. Drinking water quality and risk for human health in Pelengana commune, Segou, Mali. *Journal of Water and Health*. 2019; 17(4): 609-621. https://doi:10.2166/wh.2019.004.

[6]. WHO & UNICEF. *WHO / UNICEF Joint Monitoring Program (JMP) for Water Supply and Sanitation.* WorldHealth Organization and United Nations Children's Emergency Fund, Geneva and UNICEF, New York. 2017

[7]. National Institute of Statistics (INS).Étude nationale d'évaluation d'indicateurs socio-économiques et démographiques (ENISED) (*National assessment study of socio-economic and demographic indicators (ENISED))*. Study report, Niger. 2016; 167p.

[8]. Chippaux, J. P., Houssier, S., Gross, P., Bouvier, C. & Brissaud, F.Étude de la pollution de l'eau souterraine de la ville de Niamey, Niger(*Study of groundwater pollution in the city of Niamey, Niger*). *Bulletin of the Society for Exotic Pathology*. 2002; 94(2): 119-123.

[9]. Dégbey, C., Makoutode, M., Ouendo., Edgard, M.Pollution physico-chimique et microbiologique de l'eau des puits dans la Commune d'Abomey-Calavi au Bénin en 2009 (*Physico-chemical and microbiological pollution of well water in the Municipality of Abomey-Calavi in Benin in 2009*). *Int. J. Biol. Chem. Sci.* 2010;4(6): 2257-2271. http://dx.doi.org/10.4314/ijbcs.v4i6.64910.

[10]. Atidegla, C. & Agbossou K. Pollutions chimique et bactériologique des eaux souterraines des exploitations maraîchères irriguées de la commune de Grand-Popo: cas des nitrates et bactéries fécales (*Chemical and bacteriological pollution of groundwater in irrigated vegetable farms in the town of Grand-Popo: case of nitrates and faecal bacteria*). *Int. J. Biol. Chem. Sci.* 2010; 4(2): 327-337. https://doi:10.4314/ijbcs.v4i2.58119.

[11]. Keough, S. B, & Youngstedt, S. M. 2018 Pure water in Niamey, Niger: the back story of sachet water in a landscape of waste. *Africa*. 2018; 88(1): 38-62. https://doi.org/10.1017/S0001972017000560.

[12]. Commission Directive 2003/40 / EC of 16 May 2003 laying down the list, the concentration limits and the labeling information for the constituents of natural mineral waters, as well as the conditions of use of air enriched in ozone for the treatment of natural mineral waters and spring waters. 2003; https://op.europa.eu/en/publication-detail/-/publication/1ddc0621-7e4c-4fac-bc2b-3cd4a50e78a3/language-fr (accessed 12/12/2020).

[13]. Hubert, J., Hubert, C., Jungers, P., Daudon, M., Hartemann, P. Eaux de boisson et lithiase calcique urinaire idiopathique. Quelles eaux de boisson et quelle cure de diurèse (*Drinking water and idiopathic urinary calcium lithiasis. Which drinking water and which diuresis cure?*)*Advances in Urology.* 2002; 12(4): 692-699. https:// doi:10.1016/j.purol.2010.09.019.

[14]. Hubert, J.Quelles eaux de boisson faut-il consommer (*Which drinking water should you consume?*)*Elsevier Masson SAS.* 2010; 20: 806-809. https://doi:10.1016/j.purol.2010.09.019.

[15]. WHO. 2017 *Health safety and water quality*. Geneva.

[16]. FAO. *Standard for natural mineral waters*. 2019; http://www.codexalimentarius.net/ (consulted on 11/30/2019).

[17]. Gay, G. & Hartemann, P. Eaux et santé (*Water and health*). *HEGEL.* 2014; 4(3): 2-4. https://doi.10.4267/2042/54108.

[18]. Gawo, A. G. & Damtew Y. T. Household water treatment using adequate methods in sub-Saharan Countries: evidence from 2013 - 2016 Demographic and Health Surveys. *Journal of Water, Sanitation and Hygiene for Development, in press*. 2019; 1-10. https://doi:10.2166/washdev.2019.107.

[19]. Totaro, M., Vaselli, O., Nisi, B., Frendo, L., Cabassi, J., Profeti, S., Valentini, P., Casini, B., Privitera G & Baggiani A. Assessment, control, and prevention of microbiological and chemical hazards in seasonal swimming pools of the Versilia district (Tuscany, central Italy). *Journal of Water and Health.* 2019; 17(3): 490-498. https//: doi:10.2166/wh.2019.208.

[20]. Some, I. T., Banao, I., & Gouado, I.Composition physicochimique des eaux de boisson conditionnées commercialisées à Ouagadougou (Burkina Faso) (*Physicochemical composition of packaged drinking water marketed in Ouagadougou (Burkina Faso)).Health Notebooks*. 2009; 19(4): 202-204. https://doi:10.1684/san.2009.0162.
[21]. Iliyasu, H. Abdullahi, B. A. & Kawo, A. H. An assessment of the physicochemical quality of some bottle water sold in Kano metropolis, Nigeria. *Bayero Journal of Pure and Applied Sciences.* 2018; 11(1): 40 - 44. http://dx.doi.org/10.4314/bajopas.v11i1.6S.
[22]. Alhou, B., Micha, J. C., Dodo A. Etude de la qualité physico-chimique et biologique des eaux du fleuve Niger à Niamey (*Study of the physico-chemical and biological quality of the waters of the Niger river in Niamey*). *Int. J. Biol. Chem. Sci*. 2009; 3(2): 240-254. https://doi:10.4314/ijbcs.v3i2.44489.
[23]. Adamou, H., Ibrahim, B., Salack, S., Adamou, R., Sanfo, S., and Liersch, S. Physico-chemical and bacteriological quality of groundwater in a rural area of Western Niger: a case study of Bonkoukou. *Journal of Water and Health.* 2020; 18(1): 77-90. https://doi:10.2166/wh.2020.082
[24]. Mijitaba, S. B., Laouali, M. S., Mahamane, A. A., Adamou, H. H., Amadou, H., Manzola, A. S., & Garba H. B. Evaluation de la qualité des "pure water" vendues à Niamey (Niger) (*Evaluation of the quality of "pure water" sold in Niamey (Niger)*). *Int. J. Biol. Chem. Sci.* 2020; 14(9): 3412-3427. https://dx.doi.org/10.4314/ijbcs.v14i9.35.
[25]. National Institute of Statistics (INS). Tableau de bord social(*Social dashboard*). Study report, 2018 Edition, Niger. 2018; 88p.
[26]. Rodier, J., Legube. B., Merlet N. L'analyse de l'eau : Eaux naturelles, eaux résiduaires, eau de mer(*Water analysis: Natural water, waste water, sea water*). Dunod Edition, Paris. 2009; 1526p.
[27]. Varol, S. & Davraz, A. Evaluation of potential human health risk and investigation of drinking water quality in Isparta city center (Turkey). *Journal of Water and Health*. 2016; 14(3): 471-488. https://doi:10.2166/wh.2015.187.
[28]. Dahhou, M., Mohammed, E. M., Mohammed, E. M., Said, G. & Souad, M. Drinking water sludge of the Moroccan capital: statistical analysis of its environmental aspects. *Integr. Med. Res*. 2016; 1-10. doi: 10.1016/j.jtusci.2016.09.003.
[29]. Varol, S. & Şekerci, M. Hydrogeochemistry, water quality and health risk assessment of water resources contaminated by agricultural activities in Korkuteli (Antalya, Turkey) district center. *Journal of Water and Health*. 2018; 16(4): 574-579. https://doi:10.2166/wh.2018.003.

MIJITABA SAHIROU Bachir, et. al. "Physico-chemical Quality of Conditioned Water Sold in the Urban Areas: A case Study of the City of Niamey (Niger)."*IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, 14(8), (2021): pp 07-15.