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Quality of packaged drinking water marketed in Douala - Cameroon

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Abstract: Quality and safety of water are very important for the health. The proliferation of conditioned drinking water in urban areas of Cameroon these years raises the problem of quality control. This research was then conducted in Douala town, to determine microbiological and physicochemical qualities of local and imported conditioned drinking water, in order to inform consumers and help them to make better choices. After the survey carried out with the population in Douala town, 32 drinking packaged water in polyethylene bags and bottles were collected and analyzed. The choice was made according to the amount of the persons using this water. The research of the total germs was done by the Plate Count Agar, the coliforms determined by the Eosin Methylen Blue and staphylococcus by the Chapman medium. The hardness, the concentration of calcium and magnesium were determined by complexometric method using tetra acetic diamine ethylen (EDTA). The pH, the turbidity and the conductivity were determined respectively by a pH meter, turbidimeter and a conductimeter. Chlorides and nitrates were measured by UV spectrometric method. According to the results obtained, consumers surveyed choose a type of brand water for economic reasons, 82 % of trademarks investigated had worst sanitary safety. The analytical results demonstrated that 76 % of water produced in Douala are soft (0°F<TH<15°F), weakly mineralized (total dissolved solid <500mg/L) with $[Ca^{2+}]$ <100mg/L and $[Mg^{2+}]$ < 50mg/L. However, 100 % of imported water analyzed were very hard (TH>43°F) and highly mineralized. Water packed in bags harbored numerous species of bacteria including *Pseudomonas cepacia*, *Acinetobacteria*, and nonpathogenic *Staphylococcus*; their densities were respectively, $23x10^3 \pm 3605{,}55$ CFU.100 mL^{-1}, $22x10^3 \pm 1732{,}05$ to $54x10^3 \pm 4582{,}57$ CFU.100 mL^{-1} and $23x10^3 \pm 2000$ CFU.100 mL^{-1}. Conditioned water produced in Douala (in bags) had the worse microbiological quality than the imported water. On the contrary they are softer than imported water.

Keywords: Drinking Water, Quality, Norms, Waterborne Diseases, Douala

1. Introduction

Water is second to oxygen as being essential for life. People can survive days, weeks, or even longer without food, but only about four days without water. Water makes up about 60% of the human body. Most of the living tissue of a human being is made up of water; it constitutes about 92% of blood plasma, about 80% of muscle tissue, about 60% of red blood cells and over half of most other tissues (Turgut *et al*., 2005).

It covers some 70% of the earth's surface, with only 3% being from fresh water sources. With the world population growing and the increasing pollution of our natural resources, we are facing a water crisis. The World Health Organization has estimated that over 1 billion people lack access to safe drinking water and about 4000 children die every day from water borne disease (Virkutyte and Sillanpa, 2006). The World Health Organization estimates that 500 million diarrhea cases reportedly taking place each year in children less than five years in Asia, Africa and Latin America (WHO, 1972-73). UNICEF estimated that about 60 % of child deaths worldwide are attributed to infectious or parasitic diseases related to water, the most frequent are gastro enteritis. About 2.3 billion of people suffer from infectious gastro enteritis each year (UNICEF, 2001). The extent of enteric diseases in different areas depends upon the extent to which water is exposed to contamination. The incidence of typhoid fever, bacillary dysentery, infectious hepatitis and other enteric infections are common and are transmitted through contaminated water. Cholera is still a wide spread water borne disease in some developing countries. There are numerous other diseases that are transmitted through polluted water. (Afia *et al*., 2006; Delolme et al., 1992). According to WHO, drinking water should be clear, colorless, odorless, tasteless and free of pathogens or other toxic chemicals (OMS, 1994).

Douala, Cameroon's economic capital, although it has a distribution network of drinking water through a national company, has in recent years, an increase in production and consumption of drinking packaged water. These water are mainly composed of spring water, treated water and natural mineral water. Each type of water is subject to specials restrictions related to its operating system, its packaging or its composition (Touridomon et al., 2009). In the city of Douala, there are several brands of drinking packaged water in plastics bottles or in polyethylene bags, produced locally or imported.

Much work has already been conducted in several countries on the quality of drinking water in order to protect the consumers (Birley, 1991; Pathak et al. 1993; Boutin, 1993; Makoutode et al., 1999): Some tests have been done on the microbiological and, or physicochemical properties of drinking packaged water in Tunisia (Khosrof and Boudabous., 1992), in Ivory Coast (Blé et al., 2009), in Algeria (Djellouli et al., 2005) and in Burkina Faso (Touridomon et al., 2009). In Cameroon, studies were mainly focused on the quality of spring water, wells, rivers and the distribution network (Nola et al. 1998; Tatkeu 2001; Sena 2001). However, the review of the literature is lacking data necessary for water quality monitoring and information management.

This study was then conducted in the town of Douala in order to determine the microbiological quality and physicochemical composition of drinking water packaged in order to highlight potential risks of waterborne diseases that the populations could be exposed to.

2. Methods and Materials

2.1. Sampling

The Douala Town is located at latitude 4° North and longitude 9° East. The relief is made up of many sedimentary rocks. It is influenced by a classical equatorial climate and made up of ferralitic soils (Mamert, 2000).

From January to April 2009, a survey was conducted among 388 consumers, 20 districts and 89 outlets in the city of Douala. It aimed to identify drinking water brands consumed most and locate the various places of purchase. Thirty two (32) brands of packaged drinking water including 25 locally produced and imported, 07 were purchased in supermarkets, power supplies around schools, markets and shops in the city of Douala. For each brand, three (03) samples were collected.

2.2. Methods

2.2.1. Microbiological Analysis

The Plate Count Agar medium (Humeau laboratory, ref. 550150300-54) was used for the enumeration of total germs in the water. The Eosin Methylen Blue (Scharlau laboratory, ref. 01-592) for enterobacteria. The Mannitol Salt Agar (Chapman medium) (Scharlau, ref. 01-116) was used for the detection of staphylococci. The API 20E galleries (Biomérеux laboratory, ref. 20100- 20160) were used for the identification of Enterobacteria.

2.2.2. Physicochemical Analysis

Chloride and nitrate ions were assayed by the spectrophotometric method using a spectrophotometer (Unicam 500). The hardness, the concentration of calcium and magnesium ion were determined by complexometric method with ethylen diamine tetra acetic acid as disodium (Na_2 EDTA).The bicarbonate content was performed from the values obtained from the full title alkalimetric. The temperature, pH, conductivity and turbidity were determined from an electronic temperature probe Testo 925, pH-meter Denver, conductivity by the conductimeter Hanna and turbidity were done by turbidimeter Hanna. A conversion by a corresponding factor of the conductivity allowed to assayed total dissolved solids (TDS).

2.2.3. Statistical Analysis

The software used was Statgraphics Centurion. The analysis of average and standard deviations allowed us to compare the physicochemical composition of different packaged drinking water. The multiple comparison test of Duncan has allowed us to compare the different drinking water standards.

3. Results and Discussion

3.1. Survey

Water packed in polyethylene bags are water consumed by a large portion of the population for economic reasons. However, the main reasons for the choice of imported water remain for their quality and availability.

3.2. Health Survey at Outlets

This study was conducted in 20 districts of the city of Douala. 82% of outlets inspected had inadequate sanitary conditions. The bags of water were spread on the ground, sometimes placed in freezers in contact with meat, fish or other foods. 52.81% of the outlets had very congested soil allowing the free movement of cockroaches, villains, lizards and mice over pallets of water. Some of these creatures came even sometimes and leave their droppings on top of these pallets behind them. In other outlets packaged water were exposed to the weather such as they were placed under the sunshine or in direct contact with rainwater. This result leads to a deposit of a huge layer of dust over the packaging of drinking water. 13.48% of the outlets were located near the garbage. Only 17.98% of the shops showed hygiene compliance. The floors and walls maintained the commercial space being ventilated with air conditioners, surfaces covered with tile.

3.3. Health Survey of Consumer

Eighty-seven per cent (87 %) of consumers revealed to take no hygienic precautions before ingestion of drinking packaged water. After our investigation, we can say that despite the fact that waterborne diseases reported by people could come from the quality of water consumed, but also that failure to follow basic hygienic rules by traders and consumers would also provide a huge source of contamination and spread of waterborne diseases.

3.4. Microbiological Analysis

In Cameroon, the drinking water standards apply to packaged drinking water are the guidelines values of WHO. Packaged water analyzed show that the water of local production do not meet the standards. Their total count rate is higher than two thousand (2000) total germs in 100 mL. According to WHO, water of good microbiological quality should contain less than two thousand (2000) total germs /100 mL.

According to table 1, 16 % of drinking packaged water of locally production are polluted. This rate is higher than that obtained by Feumba et al., (2009) on the water consumed in the district of Bonangang (13.33%) and Tatkeu (2001) on Water of network distribution of Cameroon (0%). This difference is due particularly to the influence of processing methods on the microbiological quality of water consumed and on the other hand, the state's distribution network at the time of sampling. However, some authors such as Blé et al., (2009) notice that most of these packaged water collected in polyethylene bag on the market in Abidjan have concentrations of coliforms outsized respectively values of 78/100 mL and 32/100 mL. Similarly, according to Khosrof et Boudabous (1992) mineral water of Tunisian show a pollution levels by 32%, 9.2%, 5.5% and 12% respectively due to the total germs, thermo tolerant coli forms, fecal streptococci and mold.

The results obtained in our study are consistent with those of Salim and Malik., (2008); Nola et al. (2000) and Sena (2001), who worked respectively on the bacteriological and physicochemical parameters of the mouth of the Oued Beni Messous, wells and spring water of Yaoundé and the bacteriological quality of water from springs and rivers of Dschang, Baleveng and Bafou (Cameroon). Considering these results and pollution levels observed in our study, we can say that the packaged water sold in the city of Douala are more suitable for consumption compared to Tunisian mineral waters, the waters of the Great Abidjan, marine waters, or still water wells and rivers of the Department of Menoua (West Cameroon). It is noteworthy that 87.5% of samples tested were consistent over the WHO guideline value. The results reveal (table 2) few cases of non-compliance with the standards guidelines value of WHO (WHO, 1972-73). These water at concentrations higher or lower a number of germs that are indicators of pollution: *Pseudomonas cepacia* ($23x10^3$ ± 3605.55 CFU/100 mL), *Acinetobacter spp* ($22x10^3$ to $54x10^3$ ± 1732.05 ± 4582.57 CFU/100 mL) and non pathogenic staphylococci ($23x10^3$ ± 2000 CFU/100 mL). We observed that concentrations are substantially above those required by the WHO guidelines. All organisms identified are opportunists' pathogens germs. These germs do not have direct effects on health, but under certain conditions (temperature fluctuation). They can cause many health problems such as secondary infection or acute gastroenteritis (Maul et al., 1989). Several factors could explain the contamination of either count:

We have contamination of groundwater; the water is generally more vulnerable than its peak close to the soil surface (Guiraud and Galzy., 1984). The origin of bacteria in various types of groundwater is still debated, but those would come from mid-surface transport during the infiltration of surface water to groundwater (Nola et al., 2001).

Another factor of contamination could be a deterioration of facilities or the presence of cracks in the pipes that could cause infiltration of polluted water thereby polluting the catchment (Maul et al., 1989). The absence or inadequate treatment, inadequate investment and risk knowledge, poor maintenance of the production units of bottled water are all blocking factors and risk factors for groundwater pollution.

Exposure of polyethylene bags of water to solar radiation during the sale, contributes to bacterial growth because intense heat transforms the inactive chloride ions (Blé et al. 2009).

3.5. Physicochemical Analysis

The results are compiled in Tables 3, 4 and 5. It appears from these results that the majority of water brands analyzed had the pH between 6.5 and 8.5 which are values accepted by the WHO standards. The pH was 7.18 ± 0.56 (Table 5) for imported water, 6.56 ± 0.86 for the local production of water packaged in bags and 7.43 ± 0, 50 for packaged water bottles. These changes in pH from one sample to another are due to the CO_2 content of the water. For example, we noted a pH of 6 at Badoit bottled water which was carbonated water. Indeed according to Touridomon al., (2009), a high concentration of carbon dioxide (CO_2) would contribute positively to lower the pH. The season climate, the geological land traversed and different treatments applied to safe drinking water influence the physicochemical composition of drinking water. The imported water are extremely hard, while the water of locally production are sweet (water packaged in bags) and moderately hard (water packaged in bottles). This is the case of trademarks Tanguy, Semme, Supermont, Natura, and Volcanic, Hesco water (Table 3). The analyzed imported water would be excellent for pregnant and lactating women, infants, the old persons (Benani–Nodot and Hardy, 2000). In the same idea, the results of the analysis of cations (calcium and magnesium) also show that these imported brands were rich in calcium ([Ca^{2+}]> 150 mg / L) magnesium ([Mg^{2+}] <50 mg / L) while the water of local production is low in calcium and magnesium. The low hardness of these local water is due to the chemical composition of the ground traversed.

Test results show that the anions of water imported brands were rich in bicarbonate (HCO_3^-), especially the brand that has a Badoit content of 1076.04 mg / L. The levels vary from bicarbonates 391.97 ± 306.50 for imported water, 15.20 ± 11.23 for water bags and 155.88 ± 47, 35 for bottled water produced locally. The test results showed that NO_3^-nitrate content varies from one brand of water to another. However, all observed values of nitrate meet the standards of WHO. We are seeing very high values in samples of produced water with local water brand Wally has a nitrate content of 24.56 and 17.03 for the brand Sweet Water (Table 3). This could be explained by the fact that these water brands have their point of capture in areas close to industrial discharges. The nitrate content of water varies according to season (Makoutode et al., 1999). It has been demonstrated that if a pregnant women consumes regular water rich in nitrates, it could increase the risk of methemoglobinemy in newborn baby (Rodier and al., 1996). Compared to the water of local production, the overal mineral content determined from the conductivity shows that all imported water were highly mineralized. The mean levels ranging from 0.72 ± 0.62 for imported water 0.09 ± 0.09 for water bags and 0,21 ± 0.07 for bottled water. The turbidity is 0 for imported water, 0.15 ± 0.15 for water bags. However, Table 5 shows that there is no significant difference between the imported water and water bottle wrapped in local production. The material used for packaging water locally produced bagged could be responsible for turbidity observed at these packaged water. Indeed for packaged water in bags at high temperatures or in poor storage conditions. The bags could release microparticles, which escape direct packaging and come into contact with drinking water and promoting the development of its turbidity (Blé et al., 2009).

4. Conclusion

This study allowed us to determine the physicochemical and microbiological quality of packaged drinking water sold in the city of Douala. It appears from this study that the people surveyed choose a type of brand water for economic reasons. Retail outlets and consumers had inadequate sanitary conditions. The microbiological parameter deserves strong vigilance because it represents an immediate risk to the health of consumers. It is therefore necessary to warn people of health risks. The physicochemical parameters reveals that locally produced water are soft, low mineral content: calcium and magnesium. However, the imported water was extremely hard, and highly mineralized in calcium and magnesium. More detailed studies of these packaged drinking water will have an exact idea of the quality of packaged water sold in the city of Douala.

Table 1. *Rates of water pollution according to WHO standards*

Origin of water samples	Imported	Local production
Quantity of polluted brands	0	4
Quantity of analyzed brands	7	25
Pollution rate according to WHO	0 %	16 %

Table 2. *Mean density of total bacteria (expressed as UFC/mL of water) and identification*

Samples	Golden	Ndiba	Sky Water	Cool
Mean ± SD	23.10^3 ± 3605,55	$54\ .10^3$ ± 4582,57	22.10^3 ± 1732,05	23.10^3 ± 2000
Isolated species	*Pseudomonas cepacia*	*Acinetobacter spp*	*Acinetobacter spp*	No pathogenic *Staphylococc*i

Table 3. *Physicochemical parameters of drinking packaged water (local brands)*

Parameters Brands	Tur (mg/L of SiO_2)	pH	HTT (F)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	HCO_3^- (mg/L)	Cl- (mg/L)	NO_3^- (mg/L)	NO_2 (mg/L)	Cond (µs /cm)	TDS (g/L)
Aquaba	0.00	6.89	0.4	1.6	0.96	12.2	2.87	4.66	0.08	224	0.15
Aquavita	0	6.11	0.35	1.4	0.13	17.08	0.51	0.81	0.03	57	0.04
Audes	0.40	7.00	5.40	21.6	12.96	24.4	5.21	2.39	0.12	368	0.247
Bethesda	0.41	4.27	0.617	2.45	0.23	0	2.33	8.57	0.07	57	0.04
Cool	0.08	6.80	0.9	3.6	2.16	7.32	0.15	2.25	0.00	140	0.09
Delices	0.02	7.05	5.4	21.6	12.96	12.48	13.36	1.43	0	54	0.03
Gecca	0.25	7.01	6.84	27.37	10.87	10.25	1.11	0.79	0.16	22	0.02
Glanneuse	0.01	7.01	4.6	18.4	11.04	26.108	4.68	0	0.01	135	0.09
Golden	0.17	7.02	0.5	2.00	0.59	1.61	0	0.87	0	20	0.01
Hesco Water	0	7.5	22.5	90	54	119.56	3.19	1.64	0	254	0.17
Namiwa	0	5.38	3.8	15.2	9.12	14.64	11.01	0.43	0	32	0.02
Natura	0	8.00	5.5	22	13.2	145.66	3.33	7.36	0	269	0.18
Ndiba	0.09	7.00	3.56	14.24	8.54	39.04	0.49	0.86	0	108	0.07
Sawawa	0.08	7.02	0.5	2	0.59	7.08	0.33	0.64	0.03	17	0.01

Parameters Brands	Tur (mg/L of SiO_2)	pH	HTT (F)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	HCO_3^- (mg/L)	Cl- (mg/L)	NO_3^- (mg/L)	NO_2 (mg/L)	Cond (µs /cm)	TDS (g/L)
Semme	0	8.6	14.8	59.4	35.61	246.44	18.61	2.90	0.05	517	0.346
Sky Water	0.13	6.8	0.5	2.00	0.59	36.6	10.90	3.08	0	98	0.07
Source d'Orly	0.36	4.63	4.35	17.4	10.44	4.88	6.99	3.09	0.04	511	0.34
Source de vie	0.39	7.53	3.6	14.4	8.64	2.44	0.25	1.87	0.01	75	0.05
Source du Sahel	0	7.03	4.7	18.8	11.28	43.42	7.35	1.81	0.04	73	0.05
Supermont	0	7.00	21.8	87.2	52.32	122	3.50	7.73	0	228	0.153
Sweet Water	0.24	6.7	2	8.00	4.8	12.93	6.06	17.02	0.00	344	0.23
Tangui	0	7.00	9	36	21.6	136.92	2.62	0.11	0	304	0.204
Tati Water	0.09	7.00	2.7	10.8	6.48	6.48	25.13	5.30	0.37	0.03	0.06
Volcanic	0.08	7.03	9	36	21.6	164.7	2 .11	0.98	0.21	330	0.22
Wally	0.11	6.5	2.80	11.2	6.72	10.49	62.32	24.56	0	211	0.14

TDS: Total Dissolved Solids; Tur: Turbidity; Cond: Conductivity; HTT: Hydro Titrimetric Title

Table 4. *Physicochemical parameters of drinking packaged water (imported brands)*

Parameters Brands	Tur (mg/L of SiO_2)	pH	HTT (F)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	HCO_3^- (mg/L)	Cl- (mg/L)	NO_3^- (mg/L)	NO_2 (mg/L)	Cond (µs /cm)	TDS (g/L)
Badoit	0	6	68	272	163.2	1076.04	19.77	4.10	0.02	1828	1.22
Beaupré	0.17	7.6	43.3	173.2	103.92	250.1	8.03	0	0	410	0.27
Contrex	0	7.6	110.3	441.2	264.72	322.08	10.29	1.77	0	2357	1.7
Evian	0	74	20	80	48	28548	868	300	0	527	0.35
Hépar	0	7.2	88.9	355.6	213.36	319.64	18.02	3.88	0.01	1668	1.12
Mont Blanc	0	7.5	99	39.6	23.76	319.64	2.30	0	0.01	212	0.14
Roxanne	0	7.00	15.4	61.6	36.96	170.8	11.3	1.94	0.08	359	0.24

Table 5. *Duncan test of multiple comparisons of different physicochemical parameters according to each type of drinking packaged water.*

Parameters	Imported water	locals water	
		bags	bottles
	average	average	average
Turbidity (mg/L of SiO_2)	0 ± 0^a	0.15 ± 0.15^b	0.012 ± 0.01^a
pH	7.18 ± 0.56^{ab}	6.57 ± 0.87^a	7.43 ± 0.50^b
HTT (F)	50.83 ± 39.20^a	2.82 ± 2.08^b	13.77 ± 7.15^c
Ca^{2+} (mg/L)	203.31 ± 156.79^a	11.27 ± 8.33^b	55.1 ± 28.61^c
Mg^{2+} (mg/L)	121.99 ± 94.07^a	6.27 ± 4.80^b	33.06 ± 17.16^c
HCO_3^- (mg/L)	391.97 ± 306.50^a	15.20 ± 11.23^b	$155.88 \pm 47{,}35^c$
Cl^- (mg/L)	11.20 ± 6.01^a	13.92 ± 7.43^a	6.41 ± 5.56^b
NO_3^- (mg/L)	2.10 ± 1.68^a	6.37 ± 3.97^b	3.45 ± 3.30^c
NO_2 (mg/L)	0.03 ± 0.02^a	0.05 ± 0.03^b	0.08 ± 0.04^c
Conductivity (µs/cm)	1077.29 ± 917.97^a	139 ± 104.43^b	317 ± 104.43^c
Total dissolved solids (g/L)	0.72 ± 0.62^a	0.09 ± 0.09^b	0.21 ± 0.07^c

The values which have in index exponent the different letters are significantly different ($p<0.05$) according to comparison multiple Duncan Test.

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