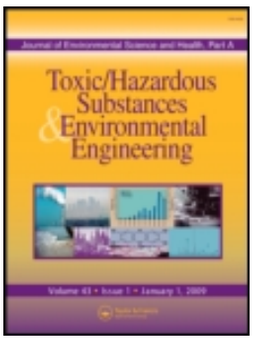

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Quality of "Sachet" Waters in the Cape Coast Municipality of Ghana

D. K. Dodoo,[1] E. K. Quagraine,[1] F. Okai-Sam,[1]
Dorsa J. Kambo,[1] and J. V. Headley[2]

[1]Department of Chemistry, University of Cape Coast, Cape Coast, Ghana
[2]National Water Research Institute, Saskatoon, Canada

To determine the quality of sachet water samples in the Cape Coast municipality of Ghana, random sampling procedures were used to collect 180 samples from 29 brands produced in the municipality from 1999 to 2004. For any particular year, each tested brand was sampled three times at intervals of not less than 2 weeks (usually monthly) between the months of March to June. Forty-five percent (45%) of the brands subjected to bacteriological examination contained coliform bacteria for one sampling period or another during the period of investigation. The coliform contamination seemed to be more prevalent with some particular brands. Three out of seven brands examined in 2004 also recorded the presence of *E. coli*. Exceedances were recorded for WHO drinking water quality guidelines for pH (6.25–7.93) in 2002 and for conductivity (67–306 μS cm^{-1}) in 2002 and 2004. Total hardness values for all sachet water brands were less than 100 mg/l $CaCO_3$ and therefore below the WHO limit for potable water. None of the samples seems to pose any health dangers as far as the major cations; sodium (17.4–19.1 mg/l), potassium (5.7–6.2 mg/l), calcium (8.0–24.0 mg/l) and magnesium (19.9–50 mg/l) are concern. Apart from nitrite, for which some exceedances were recorded and phosphate which does not have an established WHO guideline, the measured major anions (i.e., chloride: 1.57–37.7 mg/l, sulfate: 0.33–44.33 mg/l and nitrates: 0.005–0.70 mg/l) were within the WHO drinking water guideline. No exceedances were also recorded for iron and lead. In general, the high quality claimed for sachet waters could not be confirmed based on the measured physico-chemical and bacteriological properties. The variable quality and in some cases, poor water quality observed, likely reflects the fact that the sachets are not always bagged under scrutinized sanitary conditions.

Key Words: Sachet water; Coliform bacteria; Water quality; Physicochemical and bacteriological parameters.

Received July 18, 2005.
Address correspondence to E. K. Quagraine, Department of Chemistry, Brandon University, Brandon, Manitoba, Canada R7A 6A9, Ghana; E-mail: ekquagraine@yahoo.com

INTRODUCTION

Safe drinking water remains inaccessible for about 1.2 billion people in the world.[1] Gadgil and Derby[2] have suggested that the actual number of people without access to safe drinking water is likely 2 billion, or 33% of the world population. The latter values include people who receive tap water that is contaminated in urban centers of the developing world. This problem is a growing concern as about 400 children below age 5 die per hour in the developing world from waterborne diseases.[3,4]

In Ghana, due to poor or non-existing waste sewage disposal, surface water supply for commercial water treatment is usually heavily polluted. Furthermore, there is little maintenance of broken or leaking pipes, especially close to gutters and drainages. The quality of available tap water is therefore questionable and this may pose health concerns. To remedy the situation small scale industries have marketed "Purer Water" contained in electrically sealed nylon sachets. These sachets are generally considered by the public to be a safer source of potable water. Previously, water was sold from cups or in hand-filled, hand-tied, polythene-bags. The sellers blew air into polythene bags before filling, thereby introducing germs.

People living in and around Cape Coast (in Ghana) have experienced water shortages over the past 2 decades and express genuine concerns about the quality of tap water supplies. The sale of water in sachets is therefore well patronized in the municipality. Different treatment processes are employed for sachet water production depending upon the type of water source. The main source is tap water and the treatment processes are usually physical in nature. The latter involves aeration, and single or double filtration using porcelain molecular candle filters or membrane filters. Sometimes but rarely, disinfection before bagging is also carried out. Other treatments like pH correction, iron removal and the likes are seldom performed.

In some cases however, spent filters from the treatment processes are not replaced in a timely manner. Furthermore, it is alleged that tap water is simply sold without treatment in some sachets. In view of the proliferation of sachet water producers in Ghana, questions are raised about the quality of water. This is a topic of growing concern as some products are found on the market without approval by the Foods and the Drugs Board of Ghana (FDBG).[5,6]

Furthermore, some sachets on the market are known to be produced in areas of questionable conditions.[6] Various tests have shown that many processed waters have low mineral content and others are contaminated with microorganisms.[7–10] For example, drinking water sold in the streets of some municipalities in Ghana (e.g., Kumasi) contained fecal coliforms in some sachet waters.[10] The total viable counts (TVC) of heterotrophic bacteria present in tested sachet waters in Kumasi were within the range 2.0 to 6.33×10^5.[10] Similarly, exceedances to WHO guidelines were reported for sachet water in

Nigeria for pH and some chemical parameters (i.e., aluminum, fluoride, and cyanide).[11]

This paper presents the findings of investigations to examine the physical, chemical and bacteriological quality of various brands of sachet water in the Cape Coast Municipality of Ghana. It is anticipated that the results will provide supporting information to guide surveillance agencies and policymakers in water quality management in Ghana. The intent is that the study will promote awareness in the general public about the quality of sachet water in the municipality.

MATERIAL AND METHODS

Sample Selection

Random sampling procedures were used to select a total of 180 samples from 29 brands of sachet water from vendors within the Cape Coast Municipality of Ghana. The period of investigation was from 1999 to 2004. Details of the sample collection within the period are outlined next. For any particular year, each tested brand was sampled three times at intervals of not less than 2 weeks (usually monthly) between the months of March to June.

In 1999, six brands of sachet water namely; Nsupa, Helaman, Coastal, Irish, Crystal and Annet were examined. Apart from Crystal, all these brands were re-examined in 2000 together with 10 new ones namely; Ahodzen, Meridian, Agape, Wata, Bless, Silver, Honsal, Solace, Jordan, and Star Living. In addition to Nsupa, Coastal, Irish, Solace, Star Living and Ahodzen which had been studied previously, six other brands (i.e., Kings, Mega, Satisfier, Jabalk, Nova and Silver) were included in 2001. Fourteen brands were investigated in 2002 and only three (Akwaaba, Superdox and Nhyira Nsu) were new. For logistical reasons, only three sachet brands- Meridian, Nsupa and Superdox were examined in 2003. In 2004, 10 brands were studied, of which 5 (namely Sobak 69, lovely, Cool, Aqua Fresh and Delta Spring) were new. Three brands of bottled water (Voltic, Kakum and Rex Mineral waters) and tap water supplied by the Ghana Water Company Limited (GWCL) were also analyzed for comparison.

METHODS OF ANALYSIS

Bacteriological

Bacterial examination of the water samples were conducted using the plate count method with lauryl broth or agar medium,[12] and/or by the multiple-tube method.[13,14] For any particular year, three different samples of each brand studied were purchased and examined within the months of March to June. In

Table 1: Number of Colony Forming Units (CFU) $\times$ 10^3 per ml for different brands of sachet water, at different times after manufacture, and under different storage conditions.

Brands	Wk1α	Wk1β	Wk2α	Wk2β	Wk3α	Wk3β	Wk4α	Wk4β	Wk5α	Wk5β
Annet										
Sun	1	6	0	0	0	5	0	0	0	0
Room	1	6	0	0	0	2	0	0	0	1
Lab	1	6	0	0	0	0	0	3	0	0
Lovely										
Sun	0	0	0	0	1	4	0	0	0	0
Room	0	0	0	0	0	0	0	0	0	0
Lab	0	0	0	0	0	0	0	0	0	0
Aqua Fresh										
Sun	0	0	0	0	0	0	0	0	0	0
Room	0	0	0	0	0	0	0	0	0	0
Lab	0	0	0	0	0	0	0	0	0	0
Mega										
Sun	0	0	0	0	2*	11*	0	0	0	0
Room	0	0	0	0	0	0	0	0	0	0
Lab	0	0	0	0	0	1	0	0	0	0
Coastal										
Sun	0	1	0	0	0	0	0	0	0	0
Room	0	1	0	0	0	0	0	0	0	0
Lab	0	1	0	0	0	0	1	98	0	0
Wata										
Sun	1	30	0	0	2*	5*	0	0	0	0
Room	1	30	0	0	0	0	0	1	0	0
Lab	1	30	0	0	0	0	0	0	0	0
Solace										
Sun	**	**	**	**	5	30	0	0	0	32
Room	**	**	**	**	28	37	32	105	1	71*
Lab	**	**	**	**	5	34	7	86	2	103*

αrepresents 18 hours of incubation.
βrepresents 48 hours of incubation.
*Indicates the presence of *E. coli*.
**Indicates an uncountable number of colony forming units.

2004 however, 7 of the 10 brands studied that year (see above) were selected for more detailed bacteriological examinations. A batch of each of the seven brands was tested on a weekly basis over a 5-week period. For each week, two counts were made—18 hours and 48 hours after incubation at 37°C. Furthermore, the shelf life of these brands stored under three different conditions; namely the sun (40°C), room (28°C) and in the laboratory (28°C) was evaluated in duplicate counts (See Table 1 for the average counts for the various conditions). Bacteriological analysis were conducted on 22 brands of the 29 brands sampled from 1999–2004.

Physical Parameters

Measurement of pH was done immediately after the samples were received at the laboratory, using a calibrated Horiba Compact B-212 pH meter (Kyoto,

Japan). Color (Hazen units) was measured with DR/2000 spectrophotometer (Hach Company, Loveland, Colorado, USA). The turbidity of each sample was determined using a Hach Model 2100P portable turbid meter (Hach Company, Loveland, USA). A Hach conductivity/TDS Meter 4600 was also employed for the measurement of conductivity and total dissolved solids (TDS). Dissolved oxygen (DO) and biochemical oxygen demand (BOD) were determined using a portable Dissolved Oxygen-14P meter (Toa Co. Ltd., Tokyo, Japan).

Chemical Parameters

Total alkalinity was determined using a titrimetric method and expressed in terms of mg/l $CaCO_3$. Chlorides levels were determined by titrating against standard silver nitrate and using potassium chromate indicator solution (from pink to yellow end-point). Calcium, magnesium and total hardness were determined by the EDTA titrimetric method. Sulfate concentrations were measured using a Hach DR/2000 spectrophotometer (Hach Company, Loveland, USA) at $\lambda = 450$ nm based on the barium sulfate turbidity method. Nitrites and nitrates were determined spectrophotometrically using the diazotization method and cadmium reduction followed by diazotization, respectively.[13,15] Lead was determined spectrophotometrically at λ_{max} 520 nm, after chloroform extraction as a lead-dithizonate complex. Iron was determined using an Atomic Absorption Spectrometer (model AA872AAS) by Philips Electronics Co. Ltd., UK.

RESULTS AND DISCUSSION

With the exception of the bacteriological examination in 2004, the mean for a given parameter for the three sampling periods was calculated for each brand in the specified year. The results for the various tests conducted are discussed in turn next.

Bacteriological Tests

Escherichia coli (*E. coli*) is accepted as the indicator organism of choice for fecal contamination of water and for possible presence of intestinal disease-causing bacteria, viruses and protozoa.[3,16,17] Since complete identification of *E. coli* is complex and time consuming, an alternative to counting *E. coli* is to identify and enumerate fecal coliform in a given water sample. Many different regulatory bodies, including WHO, recommend that both fecal and total coliform must not be detectable in a 100-ml potable water sample.[17] The allowable limit for general bacteria population expressed as background colony counts on a heterotrophic plate count by Ontario Government (Canada) is 500 CFU per ml.[18] It is shown below that some of the sachet water brands tested throughout the study period did not meet these guidelines for water potability.

In 1999, five (5) out of the 18 (i.e., $\sim 28\%$) samples examined contained coliform bacteria. These were all from two brands; Annet which recorded 2–10

and Irish, 26–48 total coliform counts per 100 ml of water. The Irish brand recorded coliform bacteria for each of the three sampling months (March, April and May), with the highest total count being recorded in April. No "fecal" coliform was however detected in 1999, suggesting that these bacteria were not from a fecal origin. In 2000, none of the 15 brands of sachet water (including Irish and Annet) contained detectable levels of coliform bacteria.

Out of 14 brands analyzed in 2002, three namely; Coastal (average 2.2 MPN index per 100 ml), Meridian (average 5.5 MPN index per 100 ml) and Bless (average 9.1 MPN index per 100 ml) promoted coliform bacteria growth. Only Meridian and Bless, however, showed coliform growth in April. Confirmatory tests showed that the coliform contamination was of a fecal origin for Meridian, but not for Bless. In May, all three brands showed coliform contamination. The coliform bacteria were of a fecal origin for Bless and Coastal, but non-fecal for Meridian. With the exception of Coastal, which indicated the presence of coliform bacteria, there was a general improvement in potability in June, following the onset of the first rain after a prolonged drought. Although it appears that seasonal changes could be related to the variation in coliform contamination, other factors may also contribute to the observed levels. The latter likely includes the lack of strict adherence to sanitary conditions during sachet water production. Nevertheless, the findings clearly indicate that the potability of at least some brands is uncertain and hence there is a need for constant monitoring to ensure that safety guidelines are met. According to U.S. Environmental Protection Agency (USEPA) guideline, not more than 5% of samples in a month period should test positive for coliform.[19]

In 2003, all 3 brands of sachet water examined showed the presence of coliform bacteria: Superdox (48 counts per ml), Nsupa (35 counts per ml) and Meridian (only marginally with 1 count per ml). Rex Mineral bottled water also recorded coliform bacteria of 20 counts per ml. A tap water sample at the University of Cape Coast, contained 484 counts per ml.

The results obtained for the bacteriological tests conducted in 2004 are outlined in Table 1. Out of the 7 brands, only one, namely Aqua Fresh, did not show detectable bacteria activity. Lovely, seemed to have been the next brand with fewer bacteria colony forming unit; and this occurred only transiently during the third week. Although the bacterial activity for Coastal brand was also generally low, at one instance (i.e., the 48 hour-sample for Week 4 stored under laboratory conditions) a high count of 98×10^3 CFU per ml was recorded. Mega and Wata showed the presence of *E. Coli* in the third week for samples stored in the sun. Solace also showed the presence of *E. Coli* and at a higher concentration. For the latter however, these occurred in samples stored under laboratory and room conditions.

In general, there appeared to be a greater increase in the bacterial growth for samples stored under the sun than those stored under laboratory and room conditions. However, an exception was observed for Solace and Coastal

brands in which storage under room and laboratory conditions were more favorable. There were no obvious trends of colony forming activity as the weeks progressed.

PHYSICAL PARAMETERS

Color/Turbidity

The off color observed in some drinking water sources is often due to either dissolved organic matter or metallic ion such as iron and manganese. The presence of color in potable water is aesthetically objectionable to the consumer. The WHO standard is a maximum of 15 True Color Units (TCU). Turbidity on the other hand is caused by the presence of particulate matter such as clay, silt, colloidal particles, plankton and other microscopic organisms.

During the period of investigation, there were no observed exceedances to the WHO drinking water quality guideline for turbidity (i.e., 5 NTU). However, in 2000, the turbidity of 10 of the sachet brands (~67%) tested was higher than tap water (0.42 NTU). The NTU recorded values for these brands ranged from 0.9 (Ahodzen) to 2.7 (Agape/Irish). An example of the range of values observed for the turbidity and color in 12 brands of samples is illustrated in Figure 1 for samples collected in 2001. The turbidity results were generally higher in 2001 as compared to 2000. The values ranged from 1.7 to 4.0 NTU, with Irish and Nova recording the highest value. The turbidity level in the tap water was also of the same magnitude as the two samples. In general, there was lower turbidity/color values in the 2002 samples compared to previous years

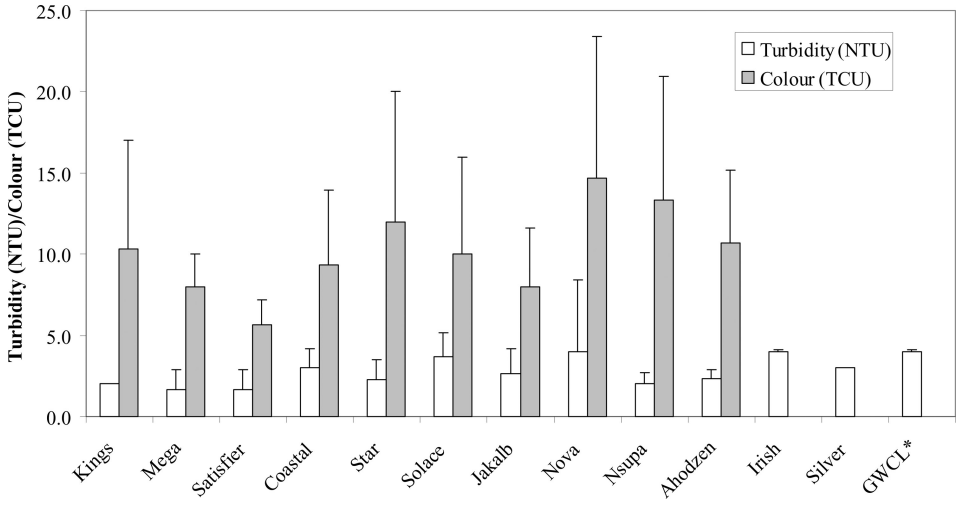

Figure 1: Turbidity and color levels of 12 brands of sachet water collected from Cape Coast Municipality in 2001. *Tap water supplied by GWCL for comparison.

of the study. This is particularly interesting, considering that the municipality experienced drought that year.

pH

With the exception of the year 2002, the pH readings of the sachet waters investigated were all within the WHO recommendation of 6.5–8.5 for drinking water. However, the values that typically ranged from 7.0 (Nsupa) to 7.9 (Solace) were generally higher than that of tap water supplied in the locality (i.e., 6.7). In 2002, 50% of the brands studied were below the recommended WHO pH minimum for drinking water. Bless and Star recorded the least value of 6.25.

Conductivity/Total Dissolved Solids (TDS)

The range of values observed for the conductivity of the sachet waters for 1999, 2000, 2001, 2002 and 2004 were: 193 (Nsupa) to 216 (Crystal); 109 (Rex) to 247 (Jordan); 133 (Mega) to 226 (Ahodzen); 201 (Akwaaba) to 263 (Crystal); and 67 (Delta) to 306 μS/cm (Sobak); respectively. The range of conductivity of tap water samples in the Cape Coast municipality during the study period was 208 to 222 μS/cm. Thus, although the tap water samples were all within the WHO guideline of 250 μS/cm for drinking water,[20] exceedances to the WHO guideline for conductivity were recorded for some sachet waters. The highest conductivity recorded during the period of investigation was 415 μS/cm and was recorded for one bottled water (Voltic) in 2000 (see Fig. 2). TDS concentrations for the sachet waters were typically in the range 90–130 mg/l.

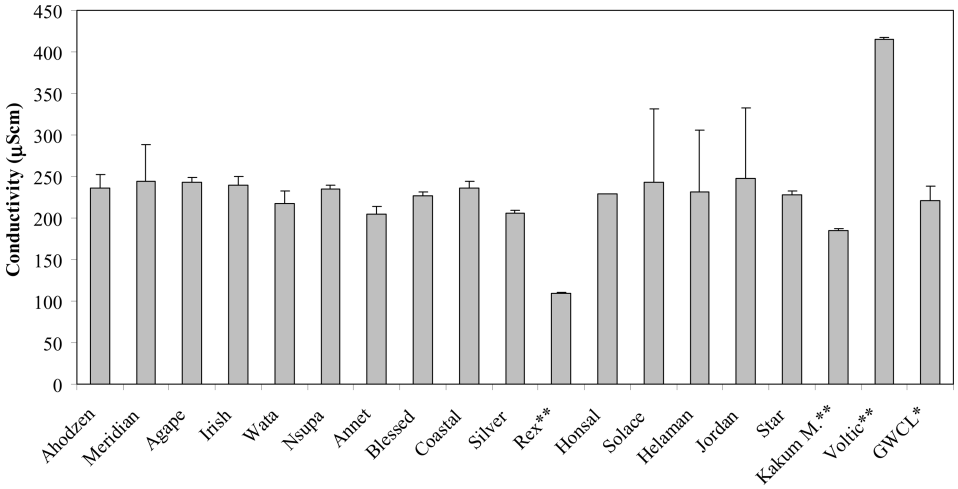

Figure 2: Conductivity of 15 brands of sachet water collected from Cape Coast Municipality in 2000 together with tap water supplied by the local water corporation (GWCL)* and three bottled water (Rex, Voltic and Kakum Mineral)**.

Alkalinity/Total Hardness

The determination of alkalinity provides an estimation of the levels of hydroxides, carbonates, and bicarbonates salts of Ca, Mg and K. The range of alkalinity values (in mg/l $CaCO_3$) in the sachet waters for 2000, 2001, 2003 and 2004 were: 30.0 (Helaman) to 64.0 (Star Living); 27.7 (Nova) to 38 (Mega/Jakalb); 20.0 (Nsupa) to 50 (Meridian); and 30.0 (Cool) to 270 (Sobak), respectively. The alkalinity of tap water measured in 2000 and 2003 were 54.3 and 20 mg/l $CaCO_3$, respectively. The recorded alkalinity values in 2000 for Rex Mineral, Kakum Mineral and Voltic bottled waters were respectively 28.7, 72.7 and 78 mg/l $CaCO_3$. In 2003, the alkalinity of Rex Mineral water was measured as 20.0 mg/l $CaCO_3$.

Water hardness can be classified as soft (0–50 mg/l $CaCO_3$), moderately soft (50–100 mg/l $CaCO_3$), slightly hard (100–150 mg/l $CaCO_3$), moderately hard (150–200 mg/l $CaCO_3$), hard (200 to 300 mg/l $CaCO_3$) and very hard (over 300 mg/l $CaCO_3$).[21] Moderately hard water, containing sufficient calcium is essential for normal growth and health. Moreover, hardness gives palatability to water. However, high values of hardness arising from elevated levels of magnesium sulfate are not desirable. The latter can act as a laxative especially for new users of the supply. The WHO desirable limit for total hardness is 100–500 mg/L $CaCO_3$. The range of values for total hardness (in mg/l $CaCO_3$) for the water samples in 2000, 2001, 2002, 2003 and 2004 was: 42.7 (Kakum bottled) to 72.3 (Silver); 56.7 (Nova) to 76.7 (Coastal); 36.0 (Crystal) to 55.0 (Akwaaba); 30.0 (Superdox) to 50.0 (Meridian / Rex bottled); and 30 (Delta) to 74 (Sobak). All sachet waters studied were therefore below the WHO desirable minimum for quality drinking water.[17,22] By classification, 44% of the samples were soft and 56% moderately soft. For comparison, the values for tap water ranged from moderately soft (with a minimum recorded value of 62.5 mg/l $CaCO_3$ in 2000) to slightly hard (with a maximum recorded value of 100 mg/l $CaCO_3$ in 2003).

Biochemical Oxygen Demand (BOD)

One of the most important parameters in water quality analysis is BOD: a measure of the dissolved oxygen consumed by chemical and microbiological action when a sample of water is incubated for 5 days at 20°C in the dark. Apart from year 2002 (2–4.9 mg/l), and one instance in May 1999 when a sachet sample recorded 10 mg/l, the BOD values were generally below 2 mg/l.

Major Cations

Although a 200 mg/l sodium maximum limit is recommended by WHO for drinking water quality,[17,20,22] a level of 20 mg/l in drinking water is suggested to minimize the risk to hypertensive persons and heart patients.[23] Calcium levels as high as 1800 mg/l in water have been reported to be relatively safe for human consumption.[23] Magnesium values greater than 125 mg/L can however

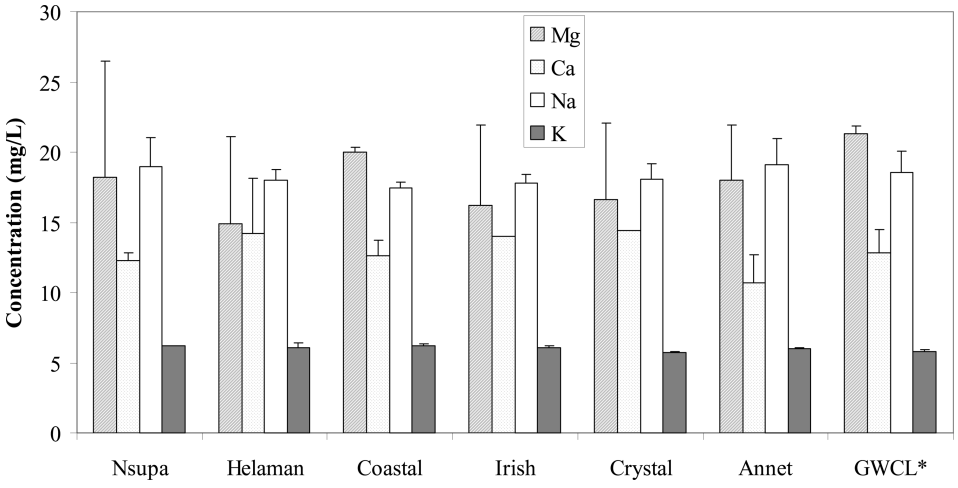

Figure 3: Major ion concentrations in 6 brands of sachet water collected from Cape Coast Municipality in 1999 together with tap water supplied by the local water corporation (GWCL)*.

exert cathartic and diuretic reactions.[24] Despite these high health-based allowable concentrations, both calcium and magnesium contribute to the hardness of water and may lead to scaling.

In general, the concentration of the major ions, sodium, potassium, calcium and magnesium did not seem to pose any direct health concerns. In the case of sodium, where health-based WHO guideline in drinking water is established, the values were well below the guideline. This general trend for the study period is illustrated in Figure 3, in which the measured values for 1999 are given. For comparison, the corresponding value is also given in Figure 3 for tap water supplied by the local water supplying company (i.e., GWCL). The concentration of both potassium and sodium in the various samples were essentially constant. The magnesium and calcium levels for the brands studied in 1999 ranged from 14.9 to 20.0 mg/l (CV = 12.4%) and 10.7 to 14.4 mg/l (CV = 10.1%) respectively. The magnesium levels in the sachet waters were all lower than that in tap water (21.3 mg/l). The magnesium concentrations in the sachet and bottled waters were generally higher in 2000 than the previous year. However, the general trends for this year and subsequent years of the study were similar to those illustrated for 1999 with only a few exceptions. Calcium concentrations were higher in about 42% of the brands of sachet water compared to tap water in 2001.

Major and Minor Anions

Chlorides and sulfates are among the major anions usually found in drinking water sources. Chlorides in drinking water originate from natural

sources, sewage and industrial effluents and urban runoffs. No health-based guideline has been reported for chloride in drinking water. However, chloride concentrations in excess of about 250 mg/l can result in taste problems and indeed that limit has been proposed by WHO to minimize such concerns.[17] Due to gastrointestinal problems from drinking water containing high sulfate levels, WHO also recommends that health authorities be notified where sulfate concentration exceed 500 mg/l.[17,20] The nitrite concentration in groundwater and surface water is normally low but can reach high levels as a result of leaching or runoff from agricultural land or contamination from human or animal wastes.[17] A WHO drinking water quality guideline of $\leq$50 mg/l nitrate has been proposed to protect against methaemoglobineamia in bottled-fed infants on short exposure. The corresponding WHO limit for nitrite is 3 mg/l. For long-term exposure, a provisional guideline of 0.2 mg/l is proposed.[17]

Figure 4 shows an example of representative data for the concentration of chloride, sulfate and nitrate in the various brands of sachet water as measured in 2000. In general, apart from a few exceptions, concentrations recorded during the study period were well below the WHO limits for these parameters in drinking water. For example, out of the 15 sachet brands and 3 bottled brands investigated in 2000, only the Annet brand (0.43 mg/l) exceeded the WHO guideline in drinking water for nitrite levels. Two other brands namely, Meridian and Coastal recorded exceedances of 0.42 and 0.35 mg/l respectively in samples collected in June; but fell below WHO limits for other sample collections. Typical

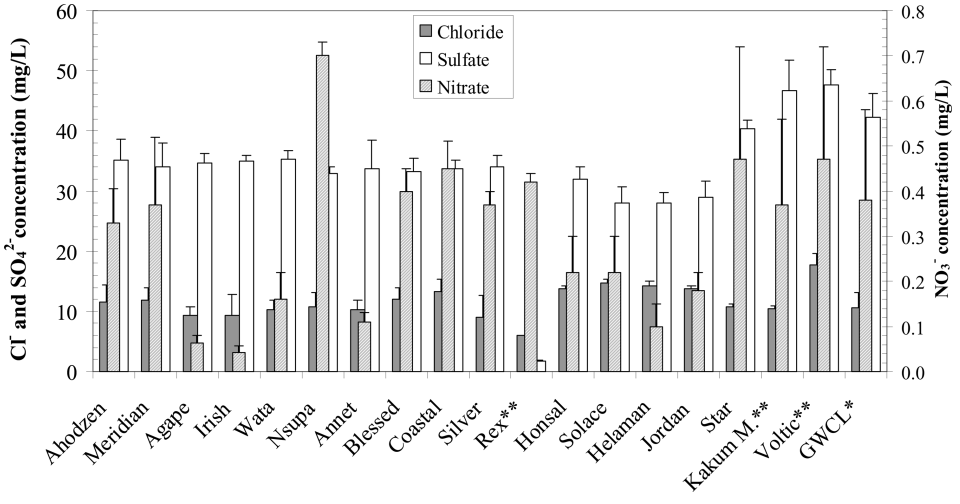

Figure 4: Chloride, sulfate and nitrate concentrations in 15 brands of sachet water collected from Cape Coast Municipality in 2000 together with tap water supplied by the local water corporation (GWCL)* and three bottled water (Rex, Voltic and Kakum Mineral)**.

values of phosphate levels (expressed as $P\text{-}PO_4^{3-}$) in sachet water brands measured were $\leq$0.06 mg/l as compared to $\sim$0.15 mg/l in tap water.

Heavy Metals (Iron and Lead)

Natural waters contain iron (Fe) at levels ranging from 0.5 to 50 mg/l. Apart from the natural sources of iron, drinking water may also contain residues from iron coagulants or the corrosion of steel and cast iron pipes used for water distribution.[17] A guideline value of 0.3 mg/l has been established as a compromise between iron's use in water treatment and aesthetic considerations.[17,22] No health-based guideline value for iron in drinking water has been proposed. However, a value of 2 mg/l in drinking water has been proposed as a precaution against excessive iron storage in the body.[17]

In year 2000, the highest recorded iron concentration was 0.07 mg/l. Out of 18 samples (i.e., 15 sachet brands and 3 bottled brands) studied in that year; only one exceeded the level of iron in tap water (i.e., 0.042 mg/l). The levels of iron in the water samples were all within WHO guidelines. The concentration of iron in sachet water samples collected in 2002, the other sampling period for heavy metals, were also well below the aesthetic-based WHO guideline of 0.3 mg/l. The values ranged from 0.6 to 3.9 μg/l. As illustrated in Figure 5 for tests in 2002, none of the levels of lead (Pb) in brands of sachet water studied exceeded the WHO drinking water guideline of 10 μg/l.[17,20]

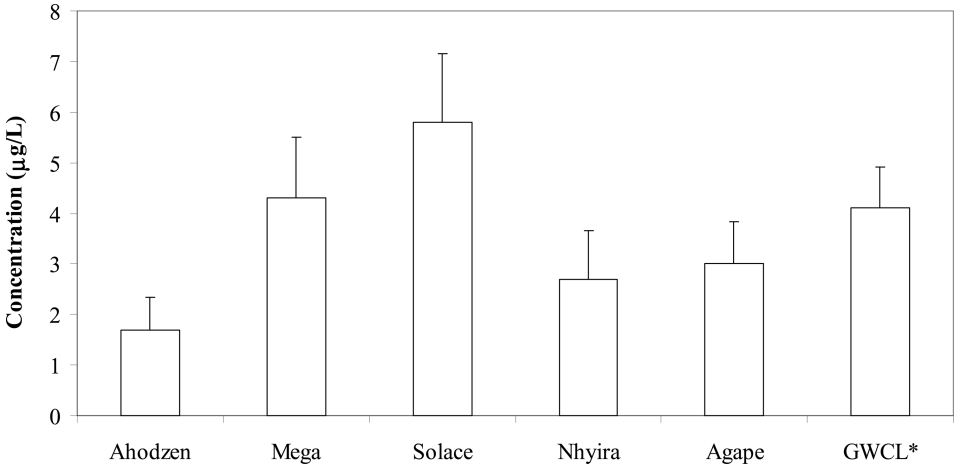

Figure 5: Lead levels in some brands of sachet water collected from Cape Coast Municipality in 2002 together with tap water supplied by the local water corporation (GWCL)*.

CONCLUSION

Although most of the sachet water producers in the Cape Coast municipality use tap water as the main water source for further purification, higher turbidity were recorded in several instances than the tap water. For instance in 2000, higher turbidity was observed in 67% of the sachet brands compared to tap water, suggesting a possible contamination from over-used filters. Some of the physical and chemical parameters measured (i.e., pH, nitrite, total hardness and conductivity) were found to fall outside the WHO recommended concentration ranges in drinking water. Ten out of the 22 brands examined contained coliform bacteria at one sampling occasion or another during the period of investigation. There was no regularity in coliform activity for the various brands between the different sampling periods; nevertheless coliform contamination appeared to be more prevalent for some brands. The presence of *E. coli* was detected in three brands. Further study is thus warranted to determine whether there are health implications for consumers in the municipality.

To help ensure the quality of sachet water, it is recommended that bacteriological analysis be conducted routinely before and after bagging. Furthermore, there is a need to ensure compliance to standards and the provision of safe water. The latter will likely entail inspection by the Municipality to confirm adherence to proper conditions and practice for the production of sachet water in Ghana.

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