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Nutrient minerals in commercially available bottled waters of Bangladesh: dietary implications

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Abstract

This study assesses the quality of drinking water from commercially available bottled waters in Bangladesh in terms of nutrient minerals and estimates their contribution in fulfilling the dietary requirements from such minerals. Ca, Mg, Na, trace element concentration and other physical parameters of the various bottled waters were investigated and compared on 13 samples of major local and imported brands of bottled water collected from local markets. It was found that imported brands had significantly high levels of bicarbonates (245 to 485 mg/l) compared to local brands (12.27 to 86.87 mg/l). Imported brands also had distinctively high levels of calcium (average concentration108.56 mg/l) and magnesium (average concentration 18.49 mg/L) concentrations compared to local brands and can fulfilupto 19.8% and 16.6% of the calcium and magnesium dietary reference intake (DRI) requirement respectively (for an average male). The DRI fulfilment from local brands hardly exceeded 3.3% for calcium and 7.3% for magnesium. The lack of mineral in local brands can be attributed to inadequate mineral amendments after extensive demineralization treatment. This study suggests that most of the local brands of bottled water in the market,poor in mineral content, may have negative dietary implications for long term consumption.

Keywords: Bottled water; Nutrient mineral; Dietary Reference intake

Introduction

For proper physiological and physicochemical functioning of the human body, dietary nutrient minerals such as Ca, Mg, Na, K, Fe, Zn, Cu, Cr, I, Co, Mo and Se are essential (NAS, 1977).These elements in combined form affect bone and membrane structure (Ca, P, Mg, F), water and electrolyte balance (Na, K, Cl), metabolic catalysis (Zn, Cu, Se, Mg, Mn, Mo), oxygen binding (Fe), and hormone functions (I, Cr) (WHO 2005). The Institute of Medicine of the US National Academy of Sciences have developed dietary reference intakes (DRI) which are provided to promote optimal health by avoiding consequences of nutrient deficiency and excess (NAS, 1997, 2004). Health consequences of micronutrient deficiencies include increased morbidity and mortality due to reduced immune defence system and impaired physical and mental development. Low intake of Ca and Mg contribute to rickets in children and osteoporosis in women worldwide (NAS, 1977, 1980). Although not commonly realized, drinking water may also contain some of these minerals in variable quantities naturally (e.g. minerals gaining access to groundwater due to their presence in earth's crust and aqueous solubility) or through deliberate or incidental addition. The micronutrients with the largest proportion of intake from drinking water relative to that provided by food are calcium and magnesium for which water may provide up to 20% of the required total daily intake. In case of deficient diets, the marginal contribution of nutrients from drinking water could become significant (NAS, 1977, 1980; WHO, 1996; NRC, 1989).

The presence of Ca and Mg in drinking water is evidentially vital. Many epidemiological studies suggest an inverse relationship between Mg and Ca concentration in Drinking water and cardiovascular (ischemic) disease mortality (WHO, 2005). Epidemiological research carried out in the US, Europe and Russia suggests that benefits may be associated with minimum level of approximately 20-30 mg/l Ca and 10 mg/l Mg in drinking water (WHO, 2005; Durlach *et al*., 1985). Drinking water standards in different countries have prescribed certain levels of these nutrient minerals to be present in drinking water (e.g. 75 mg/l of Ca and 30 - 35

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mg/l of Mg in Bangladesh Drinking Water Standards) (ECR, 1997). Bicarbonate is another desirable content in mineral water aiding various physiological functions of the human body. Slightly alkaline water plays a buffering role for acidity generated in human body as a result of certain food intakes or exercise activities and helps maintain the acid-base balance of the body. An ingestion of 300 mg/kg of body weight of bicarbonate before exercising has been found to reduce muscular fatigue and increase the performance of short- term physical exercise. Mineral water which typically contains bicarbonate greater than 600 mg/l will have these beneficial effects.

Mineral nutrients, which are naturally present in water and have certain health benefits, may be removed through water treatment processes (e.g. membrane filtration, reverse osmosis, softening etc.) and the water can potentially become nutrient deficient. Commercially available local brands of bottled waters in Bangladesh, which are generally products of demineralization process of extracted groundwater, may lack some of these useful nutrients if these minerals are not re-introduced in the water treatment process before packaging.

The consumption of bottled water has increased steadily in the last few decades all over the world (increasing almost 7% each year) despite its high price compared to tap water (Feru, 2004). In Bangladesh, bottled water first appeared in the market as 'Mineral Water' after the 1988's flood following the wide spread breakout of Hepatitis B and when tap water was perceived to be no longer safe (Hasan *et al.,* 2011). The perception of bottled water to be a safer option still prevails particularly in urban areas where the unreliability associated with municipal water supply is high either due to poor quality of water or inadequacy in water quantity supplied by the municipalities (Parveenet *et al*., 2008). In fact, nowadays the consumption of bottled water has become ubiquitous and a part of a growing social trend as a wider class of people are willing to pay the extra price for the bottled water in exchange of perceived benefits over the municipal tap water. This practically warrants an investigation into the quality of these products in terms of mineral quality. Although the nutrient mineral of drinking water options of other countries in Europe, Middle East, South East Asia and in United States are very much profiled (Wiesenberger, 1991; Azoulay *et al.,* 2001; Green and Green, 1994; Mahmood *et al.,* 2004), very little work has been done to investigate and quantify the mineral content of available drinking water options in Bangladesh and to assess its contribution to dietary reference intake (DRI). This paper aims to quantify the presence of nutrient minerals in bottled drinking water available in Bangladesh. Samples of bottled water collected from various departmental stores were analyzed in the laboratory for selected mineral constituents. Comparisons of the contribution of these constituents towards fulfilling the dietary requirements of an individual consuming these products have been made and their dietary implications have been discussed.

Materials and Methods

For the purpose of this study, 13 commercially available bottled waters, both imported and local brands collected from various departmental stores, were used as samples. The imported brands were - Evian (I1), Nestle (I2) and Perrier (I3) and the local brands were - Spa (L1), Ifad (L2), Mum (L3), Yes (L4), Jibon (L5), Pani (L6), Pran (L7), Fresh (L8), Acme (L9) and Shanti (L10). The bottled water brands were collected with their manufacturers' seals intact. The samples were tested for drinking water quality parameters as well as trace minerals. Alkalinity, Total Dissolved Solids and Total Hardness were determined using Standard Methods (Clesceri, *et al*. 1998). Line Source Atomic Absorption Spectrophotometer (Shimadzu AAS-AA6800) was used employing a Hollow Cathode Lamp (HCL) for the determination of calcium, magnesium, sodium, potassium, arsenic and Selenium. Samples were not acidified before analysis. Ion Chromatography system (Dionex ICS-900) was used for the determination of nitrite, nitrate, chloride, fluoride, bromide, sulfate and phosphate. bicarbonate alkalinity and concentration were determined using total alkalinity and pH measurements as shown below (Sawyer *et al.,* 2003; Harnedand and Scholes 1941).

Bicarbonate alkalinity (as mg/l $CaCO_3$)

$$\frac{50{,}000\left[\frac{\text{Total Alkalinity}}{50{,}000}+\left[H^+\right]-\frac{K_W}{\left[H^+\right]}\right]}{1+\frac{2K_{A2}}{\left[H^+\right]}} \quad \text{..... [i)}$$

Where, $K_w = 10^{-13.93}$ and $K_{A2} = 4.72\times10^{-11}$ at 25.5°C (Room temperature)

And, Bicarbonate (as mg/l $CaCO_3$)
= Bicarbonate Alkalinity×1.22 … [ii]

In order to determine the fulfilment of dietary requirement, a water consumption of 2 liters per day was assumed for adults (and 1 liter per day for children) as commonly used by WHO and other regulators for the purpose of risk assessment (WHO, 2011). It was also assumed that adults (male and female) consume about 1 liter (approximately two 500 ml bottles) and children consume about 0.5 liter of bottled water (approximately one 500 ml bottle) per day. This implies that the remaining drinking water requirement is being fulfilled by tap water or other sources. Such assumption was made to simulate a realistic water consumption trait for an urban population considering the fact that though an individual might be heavily dependent on bottled water, it will not fully constitute his drinking water needs. The estimated nutrient mineral contribution from different bottled waters were compared with the DRI values of the respective minerals (Table I) (NAS, 2004)

Bicarbonate concentration for all the samples as calculated using Equation (ii) are presented in the bar diagram in Fig. 1. It can be observed that the imported brands have distinctively high bicarbonate content ranging from 245 to 485 mg/L with a mean value of 323.76 mg/l. For local brands the bicarbonate concentration ranges from 12.27 to 86.87 mg/L with a mean of 36.17 mg/l. The difference in these two categories of samples is significantly pronounced with the local brands showing significantly lower levels ($p<0.00001$) compared to the imported brands. No DRI value has been set for bicarbonates and there is no requirement for bicarbonate levels in WHO guidelines or the Bangladesh standard for drinking water. However, it is well documented that drinking water with bicarbonate > 600 mg/L has positive effects on the body's acid balance system and even higher intakes can reduce muscular fatigue in athletes for short-term physical exercise (Durlach *et al.,* 1989). The imported brands in this case will be more favorable as they contain bicarbonates almost 10 times as much as the local brands of bottled waters.

Table I. Dietary Reference Intakes (DRIs) of selected mineral elements

Life Stage	Ca (mg/d)	F (mg/d)	Fe (mg/d)	Mg (mg/d)	Mn (mg/d)	Se (mg/d)	Zn (mg/d)	K (mg/d)	Na (mg/d)	Cl (mg/d)
Infants	210 - 270	0.01 - 0.5	0.27 - 11	30 - 75	0.003 - 0.6	0.015 - 0.02	2- 3	400 - 700	120 - 370	180 - 570
Children	500 - 800	0.7 - 1	7 - 10	80 - 130	1.2 - 1.5	0.02 - 0.03	3 - 5	3000 - 3800	1000 - 1200	1500 - 1900
Males	1000 - 1300	2 - 4	8 - 11	240 - 420	1.9 - 2.3	0.04 - 0.055	8 - 11	4500 - 4700	1200 - 1500	1800 - 2300
Females	1000 - 1300	2 - 3	8 - 18	240 - 320	1.6 - 1.8	0.04 - 0.055	8 - 9	4500 - 4700	1200 - 1500	1800 - 2300

Source: National Academy of Sciences, Food and Nutrition Board, Institute of Medicine (2004).

Statistical significance test (Students t-test) was carried out to determine the significance of the difference in mineral levels found in different brands. The difference was considered significant if p-value was found less than 0.05 (5% level of significance).

Results and discussion

Bicarbonates, taste and acceptability

Table II shows the physico-chemical parameters of the bottled water samples. pH of the samples ranged from 5.06 to 6.9 which shows that they are weakly alkaline. Since all the samples have a pH less than 8.3 the total alkalinity of all the samples is due to bicarbonate alkalinity (Hasan, 2011). The total dissolved solids (TDS), which is a combination anions and cations present in water, as well as total hardness of the samples showed similar characteristics as total alkalinity. As can be seen in Table II, the TDS of local brands showed a wide variation ranging from 0 to 314 mg/l; actually apart from Spa, Mum and Acme brands, the rest had a TDS below 100 mg/l. On the other hand the imported brands had significantly high ($p = 0.0016$) TDS ranges (237 mg/l to 482 mg/l). TDS is often used as an acceptability criteria of drinking water; low TDS waters generally exhibit flat, insipid taste while high TDS water is usually more palatable. Bangladesh Standards prescribe drinking water not to exceed a TDS value of 1000 mg/l (ECR, 1997) although the Food and Drug Administration, USA (FDA) requires that

Table II. Selected water quality parameters of bottled waters in Bangladesh (all values in mg/l; hardness and alkalinity in mg/l as $CaCO_3$)

Sample ID	I1	I2	I3	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
pH	6.9	6.84	5.06	6.37	6.19	5.37	5.96	6.22	6.21	6.29	5.9	6.24	6.03
Hardness (mg/l as $CaCO_3$)	210	90	360	198	24	68	<1	26	<0.5	18	<1	<1	6
Alkalinity (mg/l as $CaCO_3$)	220	201	375	13	42	71	10	44	19	44	11	31	11
TDS (mg/L)	268	237	482	314	69	126	3	61	17	36	48	110	0
Bicarbonate (mg/l as $CaCO_3$)	268	245	458	15	51	86	12	53	23	53	13	37	13
Chloride (mgl)	7.38	1.9	21.47	87.7	0.49	12.97	1.53	5.83	12.42	1.36	25.48	2.7	1.33
Fluoride (mg/l)	0.28	0.53	0.16	0.17	0	0	0	0	0	0	0	0	0
Calcium (mg/l)	194.08	17.65	113.95	32.57	0.76	4.36	0.06	1.33	0.07	1.35	0	0	0.45
Magnesium (mg/l)	39.76	11.51	4.21	17.6	2.1	2.45	0.09	2.06	0.06	1.32	0.03	0.01	0.08
Potassium (mg/l)	0.96	3.66	0.78	3.94	0.57	1.46	0.21	0.56	0.08	0.44	0.49	0.24	0.22
Sodium (mg/l)	28.86	21.56	46.85	19.82	57.18	26.46	36.87	32.44	4.67	61.56	9.08	22.6	6.46
Iron (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0
Selenium (ppb)	0.01	0.03	0.31	0.09	0.27	0.01	0.52	0	0.07	0.21	0.6	0	0

mineral waters contain between 500 and 1,500 mg/l of TDS (Wiesenberger 1991). The TDS of all the samples tested, though not satisfying the requirement of FDA, are indeed less than the Bangladesh standards. However, the local brands have been found to be nearly unpalatable due to the low TDS content. The total hardness of imported brands (ranging from 90 mg/l to 360 mg/L as $CaCO_3$) have been found to be significantly higher ($p = 0.0024$) than local brands (ranging from <1 mg/l to 198 mg/L as $CaCO_3$). Hardness is also considered an acceptability criterion in drinking water with WHO limiting its value to 500 mg/L mostly taking into account palatability and household usage factors. But water with high hardness will have other beneficial effects (as mentioned earlier) because it is indicative of high Calcium and/or Magnesium ions in water.

Calcium, magnesium and sodium

A very noticeable variation exists between the mineral contents of the two categories of samples in terms of the major nutrients found in water such as calcium, magnesium and sodium. Table II summarizes the values of the parameters tested in this study and Figure 2 depicts the comparative intakes of these minerals assuming a standard bottled water consumption rate of 1 L/day. The calcium content of the imported brands ranges from 17.65 to 194 mg/l with a mean value of 108.56 mg/l. In local brands the values ranged from 0 to 32.57 mg/l with a mean vale of 4.1 mg/l. As for the magnesium content the range and the mean for imported brands are 4.21 to 39.36 mg/l and 18.5 mg/l, respectively, for local brands 0.01 to 17.6 mg/l and 2.58 mg/l, respectively. The local brands contain significantly lower amount of Calcium and Magnesium compared to the imported brands ($p = 0.0008$ for Ca, $p = 0.0127$ for Mg). On the other hand the sodium concentrations in both local and imported brands have been found to be comparable and not significantly different ($p = 0.3552$). The range of sodium content and mean of the two categories of samples are: for imported brands 21.56 to 46.85 mg/l and 32.42 mg/l, respectively; for local brands 3.57 to 61.56 mg/l and 27.71 mg/L, respectively. The %DRI fulfilled, calculated assuming a standard intake rate for bottled drinking water for adults, for calcium and magnesium shows that the contribution of the imported brands are considerably higher (Table III). The average calcium content of the imported brands can fulfill calcium DRI

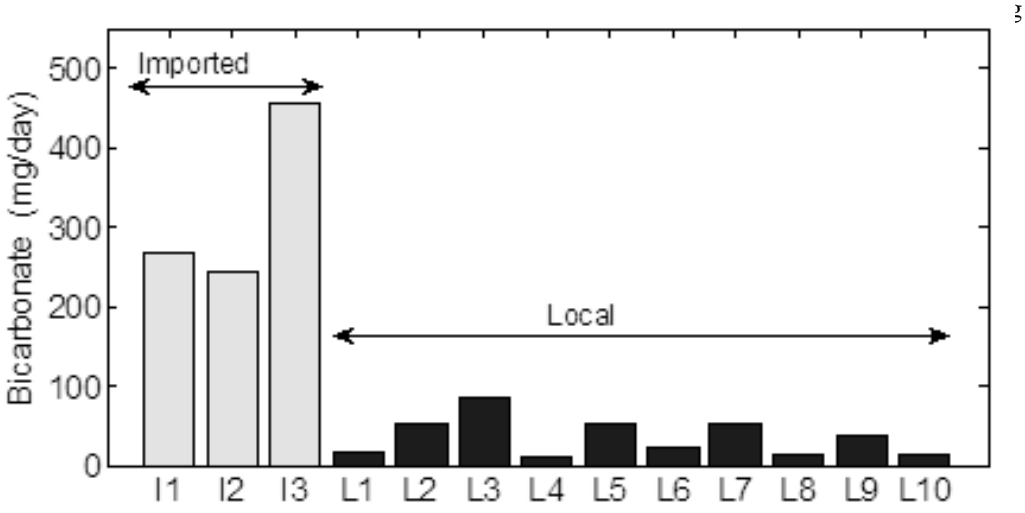

Fig. 1. Comparison of typical bicarbonate intakes (mg/day) from imported and local brands of bottled water in Bangladesh for adult males assuming a 1 l/day drinking water consumption

from 1.4% to 19.8% for adult males of various age groups. For adult males the percentage of fulfillment by local brands was found to range from 0% to 3.3% only. The % DRI fulfilment of magnesium for different age groups of adult male by the imported and local brands was 1% to 16.6% and 0.002% to 7.3% respectively. The ranges of DRI fulfillment of sodium for adult males for imported and local brands are 1.4% to 3.9% and 0.31% to 5.1%, respectively. The American Heart Association (AHA) has recommended that drinking water should contain a maximum of 20 mg/L of Na for individuals on a severely restricted Na diet (500 mg of Na per day). In this respect, both the local and imported brands of bottled water often found to exceed the 20 mg/L limit suggested by AHA and consuming 1-2 liters per day will constitute almost one-fifth of the daily sodium allowance. Thats why, an individual on a sodium-restricted diet may find some of the local and imported brands prohibitive.

The calcium levels of the imported brands Evian and Perrier have been found to be the highest in bottled waters available in Bangladesh. In order to bring the mineral quantities in locally available bottled waters in perspective, a comparison with US and European bottled water nutrients is presented in Table III. The US categories of bottled waters include spring water and mineral water. In the US, bottled waters that have TDS contents between 500 - 1500 mg/l are considered mineral waters, collected from springs are not generally mineralized further and usually contain lower levels of minerals than the bottled waters in North America (Azoulay *et al.,* 2001). In Europe, the definition of 'mineral water' is somewhat different; water with any level of mineralization is considered 'mineral water' (Azoulay *et al.,* 2001). The European Economic Community Mineral Water Regulations prohibit the processing and treatment of any water bottled from a source and depending on the mineral content in their native condition, European brands have been categorized as Low, Moderate and High Mineralization water (Azoulay *et al.*, 2001).Although some variability in mineral content exists among US and European bottled waters, both of them contained higher mineral levels compared to the Bangladeshi local brands. Table III also shows the comparison of the DRI fulfillment by the various categories of the US and European brands to the samples tested in this study.

When compared to the dietary intake of calcium, magnesium and sodium, the mineral intake was found to be dependant on the type of water consumed. For example, spring water contains very low amounts of minerals with ranges of values 0 -76 mg/l, 0 - 95 mg/l and 0 - 15 mg/l for calcium, magnesium and sodium respectively. An average adult male can fulfill %DRI requirement in the ranges of 0 - 7.6, 0 - 39.58, 0 - 1.25 for calcium, magnesium and sodium, respectively which are only slightly higher than the contribution of the local brands.

Table III. Comparison of Average Ca, Mg and Na levels (in mg/l) in Bangladesh, US and European Bottled Waters (% DRI fulfilled for adult male are shown in parentheses)

Bottled Water	Ca: Mean±SD (% DRI range)	Mg: Mean±SD (% DRI range)	Na: Mean±SD (% DRI range)
Local brands (10 samples)	4.095±9.57 (0.0 - 3.3)	2.58±5.1 (0.002 - 7.3)	27.71±18.81 (0.31 - 5.1)
Imported brands (3 samples)	108.56±72.13 (1.4 - 19.8)	18.49±15.33 (1.0 - 16.6)	32.42±10.63 (1.4 - 3.9)
North American bottled waters1			
(a) Spring waters	18±22 (0 - 7.6)	8±18 (0 - 39.58)	4±4 (0 - 1.25)
(b) Mineral waters	100±125 (0.23 - 31)	24±42 (0.24 - 54.17)	371±335 (2.4 - 91.25)
European bottled waters1			
(a) Low mineralization waters	60±40 (0.31 - 14.5)	16±19 (0.24 - 45.83)	13±13 (0.07 - 4.67)
(b) Moderate mineralization waters	262±139 (6 - 57.5)	64±37 (2.14 - 53.33)	157±197 (0.13 - 55)
(c) High mineralization waters	60±59 (0.38 - 17.6)	16±20 (0.95 - 25)	1151±153 (60 - 100*)

US Mineral waters can accommodate a greater %DRI fulfilment. For an average adult male they can fulfill DRI up to 31% for Calcium while Magnesium and Sodium intake can be up to 54.17% and 91.25% of the DRI value. It can be seen that a significant portion of the dietary mineral intakes can be ensured through the consumption of US as well as European mineral waters of different mineralization levels. Even the low mineralization waters seem to be capable of fulfilling DRI values of calcium, magnesium and sodium in the ranges of 0.31% - 14.5%, 0.24% - 45.83% and 0.07% - 4.67%, respectively when the high mineralization waters can contribute to DRI fulfilment up to 17.6%, 25% and 100% of calcium, magnesium and sodium. These values indicate that while high mineralization waters are rich in sodium, their calcium and magnesium content are not significantly higher than low mineralization waters. But the mineral contents are still greater than those of the local brands in Bangladesh.

It may be noted that the imported brand Evian has magnesium content that exceed the Bangladesh standard of 35 mg/l. However, there are no known harmful human health effects in the general public associated with the consumption of calcium and magnesium within a large range, and the nutritional essentiality of calcium and magnesium is well documented. It is the deficiency of calcium and magnesium in the local brands that can be a cause for concern, as continued consumption of these bottled waters can prevent an individual from getting essential mineral nutrients. This supplement of minerals through the consumption of bottled waters could be clinically important and any incremental supplement through drinking water maybe significant (WHO, 2005).

Other trace minerals

Potassium is generally not found in water.Trace quantities were found in both local and imported bottled waters (local:0.08 - 3.94 mg/L; imported: 0.78 - 3.66 mg/l). The DRI contributions (local: 0% - 0.09% and imported: 0.02% - 0.08%) of potassium for an average adult male indicates that none of these bottled waters are a significant source of potassium. The contribution of selenium to the DRI in both

these types of water are similarly low ranging from 0.17% to 0.25% in adults and children in imported brands and from 0.3% to 0.5% in local brands. Iron has been found to be absent in all the samples tested and therefore no DRI for Iron may be fulfilled by consuming these bottled waters. For chloride, % DRI fulfilment for adults by the imported and local brands was 0.4% to 0.6% and0.7% to 0.8%, respectively. The fluoride content of all the local brands was found to be zero except for 'Spa' which had a fluoride content of 0.17 mg/L. The fluoride content of the imported brands ranged between 0.16 to 0.53 mg/L with a mean value of 0.32 mg/L. The contribution in DRI fulfilment by the imported brands was found to be significant in this case ($p = 0.0002$). Imported brands can fulfill 8% to 16% of fluoride DRI for adults. Although the local brand 'Spa' was also found to make noticeable contribution in fulfilling fluoride DRI (4.3% - 8.5% for an average adult male)but compared to the imported brands the contribution is much less. Other physico-chemical parameters such as turbidity, phosphate, nitrate, nitrite, free chlorine, total chlorine were tested for the bottled water samples (data not shown) and, along with the parameters that have been presented in Table II, were at levels in compliance with the Bangladesh standard for drinking water (ECR, 1997).

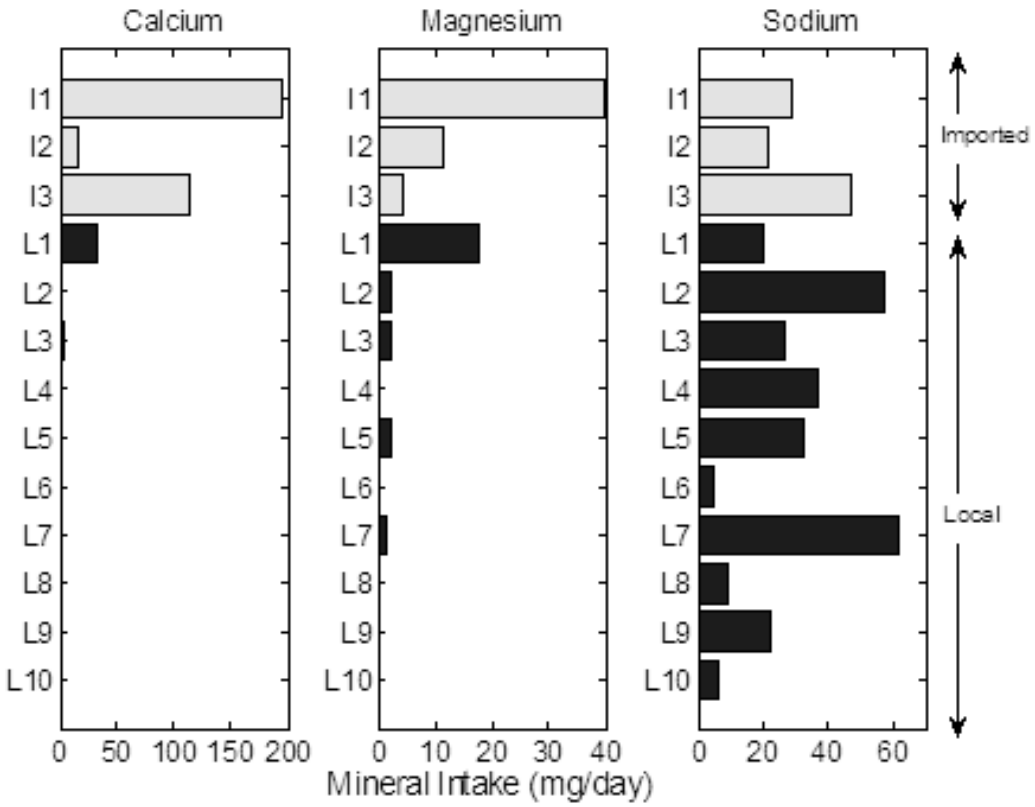

Fig. 2. Comparison of typical Calcium, Magnesium and Sodium intakes (mg/day) from imported and local brands of bottled water in Bangladesh for adult males assuming a 1 l/day drinking water consumption.

Conclusion

The study shows that the imported brands contain more Calcium and Magnesium than the local brands of bottled waters. Consequently, the imported brands have a mineral profile that fulfills the DRI requirement much better than the local brands. The local brands possess characteristics which nearly resembles those of distilled water, except for sample L1, which seems to contain more minerals compared to the

other local brands. Nevertheless the mineral content of local brands overall is very low and does not make any significant contribution in the DRI fulfilment. Even the content of calcium and magnesium in local brand of bottled water does not meet the required criteria of health benefits as suggested by epidemiological studies (WHO, 2005; Durlach *et al.,* 1985). The principal reason is that these bottled waters are usually reconstituted water by a demineralization process (typically reverse osmosis) followed by inadequate remineralization. In light of the importance of Calcium and Magnesium in delivering tangible health benefits to consumer population, reintroduction of magnesium and calcium into this demineralized water is absolutely necessary. Adding calcium and magnesium carbonates (as lime or limestone) to the demineralized water is a common water stabilization process practiced worldwide and is relatively inexpensive (NRC, 1989).

Rates of malnutrition in Bangladesh are among the highest in the world especially among children and women. Bangladeshi children suffer from high rates of micronutrient deficiencies e.g. iron, iodine, and zinc deficiency. More than 50 percent of women suffer from chronic energy deficiency and studies suggest that there has been little improvement in women's nutritional status over the past 20 years. Anaemia is also highly prevalent among pregnant and lactating women (Mahmood *et al.,* 2004). Inadequate total dietary intakes of nutrients and micronutrients are common worldwideparticularly in developing countries like Bangladesh. The requirement of calcium and magnesium are typically fulfilled though a nutritious food diet in which these minerals are abundant and highly bioavailable. But in the case of a nutrient-deficient diet, minerals from other sources (such as drinking water) can become important. Since these minerals are also highly bioavailable through water, their presence in drinking water can go a long way in reaching the goal of the ideal dietary intake of these minerals. Under these circumstances, the contribution of bottled water can be vital, only if they contain clinically important levels of these minerals. Drinking imported brands in Bangladesh can ensure a reasonable percentage of the intake of these minerals, but they are very expensive and may be out of reach for the majority of the people. Bottles of 330 ml and 750 ml of Perrier costs BDT 126 and BDT 270 respectively. A 600 ml Evian bottle costs BDT 133 whereas the standard price for a 500 ml bottled water of local brand is BDT 15 only. From the samples tested in this study, it can be said that the local brands of bottled waters, are not exactly 'mineral water' and other than preventing dehydration, their contribution towards fulfilling DRI are extremely marginal. As mentioned earlier, the main reason for the lack of nutrients is improper re-mineralization at the end of the water treatment process before packaging the water. In the light of the above discussion, mineralization of the local brands of bottled waters and making them available at reasonable prices can prove to be very beneficial for public health. And it may be particularly significant in a country like country Bangladesh where malnutrition is a major concern and bottled water consumption is on the rise.

Local brands of bottled waters in Bangladesh face additional challenges in addition to nutrient deficiency. Several studies raised concerns regarding the presence of bacteriological contamination in several randomly selected commercially available bottled waters from departmental stores and found them unsuitable for drinking purpose (Khan *et al.* 1992; Islam *et al*., 2010). Another environmental audit carried out over nine bottled water brands in Bangladesh revealed that consumer rights were not protected and the practices that manufacturers followed to control the quality of bottled water was not adequate as per Bangladesh Standard Specification for Natural Mineral Water BDS-1414:2000 (Hasan *et al.,* 2011). It should be mandatory for bottled water manufacturing companies to control the quality of product and perform prescribed tests before release of their products in the market. This study emphasizes that in addition to bacteriological and other quality control issues, re-introduction of minerals should be given due importance before making these products available for the consumers.

The local bottled water suppliers should assume the responsibility to provide information to the general public and health professionals on the complete composition of water for constituents. The attractiveness of their product should depend on the presence of beneficial substances (i.e. nutrient minerals) in desired quantities and the advertisement of the product should be based on such information. Depending on this information, the nutrition experts may suggest consumption of specific brands of water (due to the presence of beneficial nutrient minerals) or refraining from certain brands (e.g. sodium-rich brands for heart patients).

Government authorities and bottled water manufacturers should periodically monitor and analyze their waters for calcium, magnesium, trace elements, compliance with the national standard as well as international dietary guidelines. A complete catalogue of all the commercially available bottled water in Bangladesh should be made and a database of their full chemical constituents should be constructed along with their sources and treatment processes. This will assist the consumer to choose the water that would be most appropriate for their specific dietary requirements. The bottled water consumption is likely to increase in the coming years; what was considered an occasional luxury by a handful of well-off people is becoming a daily habit for an increasing number of city-dwellers. Therefore, the mineral contents in these products and their adequacy in fulfilling dietary requirements should receive due attention.

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