Research Article

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Inorganic components in drinking water collected from schools coolers and some bottled water brands sold on Sakaka markets, Saudi Arabia.

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In this work, six water samples collected from various schools and six bottled water brands collected from local supermarkets and food stores in North Central of Sakaka city, Saudi Arabia were analyzed in respect to chlorine, manganese, nitrate, chromium, sulfate, iron & copper concentrations to ascertain their suitability for human consumption. The results obtained were compared with tap water, the respected label and the guidelines of drinking water recommended by the Saudi Arabia Standards Organization (SASO) & the World health organization (WHO). With respect to manganese concentration, two of the analyzed bottled water samples failed to meet drinking water guidelines of SASO, but were below the limit set by WHO. All tested school's water samples failed to meet drinking water guidelines. Comparison of the study results with the reported label values indicated good agreement with most components but considerable variation for Manganese in the B2 brand. Low sulfate variations were found in all brands. Continuous assessment of public water quality on routine basis is imperative to reduce the contamination of water and eliminate health problems.

Key words: Components, water quality, Saudi Arabia.

Water is an essential nutrient, more important to life than any of the others, Safe and quality drinking water is essential for healthy life, but when contaminated it become a major risk for many diseases (Balbus and Lang, 2001).

Drinking water is derived mainly from 2 sources; surface waters (rivers) & ground water, which represents the main source of drinking water in Saudi Arabia (AI-Abdula'aly, 1977).

All water contains natural contaminants, which are mainly inorganic contaminants, but ground water is less vulnerable to pollution than surface water, There are several manmade potential sources that may cause contamination of drinking water; these include fertilizers, pesticides, animal & human wastes (Zubari et al.1994; Pritchard *et al.* 2007).

The basis on which drinking water safety

is determined is national standards or international guidelines. The most important international guideline is the WHO guidelines for drinking water quality; these guidelines are revised on a regular basis and are supported by range of detail documents describing many aspects of water safety (WHO. 1993).

In Saudi Arabia, the (Saudi Arabia Standards Organization (SASO), developed drinking water standards for both bottled and un-bottled water to define a quality of water that sustains a healthy population. These standards set limits for permissible and maximum contaminants level of chemical elements and indicator microorganism that endanger the health of consumers. A substantial number of these standards are based on the World Health Organization international standards for drinking water (SASO. 1984). The present study was conducted to evaluate the quality of water in selected schools and some of bottled water brands marketed in Sakaka city, and examine their compliance with local and international standards including SASO, (1984) and the WHO (1993) guidelines for drinking water.

MATERIALS AND METHODS

Six water samples were collected from various schools and six brands of bottled water were bought from local supermarket in Sakaka in North Central of Saudi Arabia. All school names and bottled water brands has been replaced with code names in order to avoid any commercial consequences, the school's water samples were coded S1, S2, S3, S4, S5 and S6 and the bottled water samples were coded B1, B2, B3, B4, B5 and B6.

The concentrations of chlorine, manganese, nitrate, sulfate, chromium VI, bromine, iron, and copper were determined using Hach Lange DR 2800 spectrophotometer (Hach Lange GmbH, Düsseldorf, Germany). The analytical method used & their detection limits for all analytes are given in Table 1.

Statistical analysis:

Data were expressed as mean ± standard deviation (S.D.) of three independent experiments. All analyses were carried out using GraphPad Prism (version 5.00 for Windows, GraphPad software Inc., San Diego, CA, www.graphPad.com.)

RESULTS & DISCUSSION

The objective of the current study was to evaluate the inorganic components of six bottled water brands collected from local markets and six water samples collected from schools coolers in Sakaka, Saudi Arabia and the obtained data were compared with the respected label, SASO standards & WHO guidelines for drinking water.

It is well known that high level of trace metal in food and drink can cause serious health problem. For example, it has been reported that asthma can be triggered by exposure to chlorinated water (Greer, F.R., and Shannon, M., 2005). Episodes of dermatitis have also been associated with exposure to chlorine and hypochlorite (Eun et. al. 1984. Watson and Kibler 1933). All bottled water samples contained less than 0.07 mgL⁻¹ of chlorine, a value far below the limit of SASO standards of 250 mgL⁻¹ & WHO guidelines of 5 mgL⁻¹. (Fig. 1)

All school's water samples contained less than 0.02 mgL⁻¹ of chlorine, a value far below the limit of SASO standards of 250 mgL⁻¹ & WHO guidelines of 5 mgL⁻¹. (Fig. 2)

With respect to manganese concentration, two of the analyzed bottled water samples failed to meet drinking water guidelines of SASO of 0.05mgL⁻¹.

Water sample B2, B4 & tap water showed the highest measured manganese concentration of 0.2 mgL⁻¹, 0.1 mgL⁻¹ & 0.31mgL⁻¹ respectively. These values exceed the SOSA limit by 4, 2 & 6 times respectively. (Fig. 3)

All tested school's water samples failed to meet drinking water guidelines of SASO of 0.05mgL⁻¹. Water sample S5 & tap water showed the highest measured manganese concentration of 0.35mgL⁻¹ & 0.31mgL⁻¹ respectively. (Fig.4)

Wasserman found that elevated level of manganese in drinking water affect the intellectual functions in 10 year old children in Bangladesh (Wasserman et al. 2006).

Nitrate concentrations measured in all bottled samples were below the limit of SASO standards of 45mgL⁻¹ & WHO guidelines of 50mgL⁻¹. Tap water and water sample, B4 showed the highest measured nitrate concentration of 6 mgL⁻¹ & 0.8 mgL⁻¹ respectively a value that exceeds the reported label value of less than 0.1 mgL⁻¹. (Fig.5)

Nitrate concentrations measured in all school's samples were below the limit of SASO standards of 45mgL⁻¹ & WHO guidelines of 50mgL⁻¹. Tap water and water sample, S1 showed the highest measured nitrate concentration of 6mgL⁻¹ & 2.1mgL⁻¹ respectively. (Fig.6)

Nitrate is reduced to nitrite in stomach, and nitrite is able to oxidize hemoglobin to methemoglobin, which is unable to transport oxygen, causing the blue baby syndrome or methemoglobinemia (Sadeqa, M, et. al, 2008, Alabdulaaly, A, 1997).

All bottled water samples contained less than 0.01 mgL⁻¹ of chromium, values far below the limit of SASO standards of 0.05mgL⁻¹, WHO guidelines of 0.05mgL⁻¹. Tap water showed the highest measured chromium concentration of 0.03mgL⁻¹.

Analyte	units	Analytical method	instrument	Detection limit
Chlorine	mg L⁻¹	N, N-diethyl-p-	Spectrophotometer ^a	0.02 to 2.00 mg L ⁻¹
Manganese	mg L ⁻¹	phenylenediamine (DPD)	Spectrophotometer ^a	0.1 to 20.0 mg L ⁻¹
Nitrate	mg L ⁻¹	Periodate oxidation	Spectrophotometer ^a	0.3 to 30.0 mg L ⁻¹
Chromium VI	mg L ⁻¹	Cadmium reduction	Spectrophotometer ^a	0.01 to 0.700 mg L ⁻¹
Sulfate	mg L ⁻¹	1,5-	Spectrophotometer ^a	2 to 70 mg L ⁻¹
Iron	mg L ⁻¹	diphenylcarbohdrazide	Spectrophotometer ^a	0.03 to 3.00 mg L ⁻¹
copper	mg L ⁻¹	Sulfa Ver 4	Spectrophotometer ^a	0.04 to 5.00 mg L ⁻¹
		1,10-Phenanthroline		
		Ricinchoninate		

Table: 1. The analytical methods and their detection limits for all analytes.

^a Hach Lange DR 2800





Figure: 2. Chlorine concentration in school's water samples



Figure: 3. Manganese concentration in bottled water samples



Figure: 4. Manganese concentration in school's water samples



Figure: 5. Nitrate concentration in bottled water samples







All school's water samples contained less than 0.04mgL⁻¹ of chromium, values far below the limit of SASO standards of 0.05mgL⁻¹, WHO guidelines of 0.05mgL⁻¹.

Water sample S5 & tap water showed the highest measured chromium concentration of 0.038mgL⁻¹ & 0.03mgL⁻¹ respectively. Several epidemiological studies has been found association between occupational exposure to chromium (VI) compounds and mortality due to lung cancer (Luippold et al. 2003)

Sulfate concentrations measured in all bottled and school's water samples were below the limits set by SASO standards of 250 mgL⁻¹ and the WHO guideline for sulfate was not established because sulfate is not of health concern at levels found in drinking water.

Tap water showed the highest measured sulfate concentration of 425 mgL⁻¹, a value exceeds approximately 2 times the SASO standards limit of 250mgL⁻¹.

Sulfate is generally harmless, except its effect on taste. At levels above 1000 mg/L, there may be laxative effects that can lead to dehydration and gastrointestinal irritation and is of special concern for infants. No healthbased guideline value for sulfate in drinking water is proposed by WHO. However, because of the gastrointestinal effects resulting from the ingestion of drinking water containing high sulfate levels, it is recommended that health authorities be notified of sources of drinking water that contain sulfate concentrations in excess of 500 mg/L (Arthur, 1971).

None of the water samples that were analyzed showed any significant level of iron or copper & the measured values where below the limits set by both SASO standards & WHO guidelines for drinking water.

Conclusions:

The present study has demonstrated that most of the measured values of inorganic components in the six bottled water samples collected local markets and six water samples collected from schools in Sakaka of north central of Saudi Arabia were in compliance with the national & international legislation acceptable limits except for Manganese.

Manganese levels in all of the tested samples contain level greater than (at least 2.4 times) the limit set by SASO, although still less than the limit set by WHO.

In this study only the inorganic components of drinking water were partially addressed, whereas the organic components & the microbial were not investigated at all.

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