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Elemental Variation on Bottled Drinking Water Sold in Al-Qassim Region, Saudi Arabia

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Abstract: This study is focused on the elemental analysis of fourteen-branded domestic bottled water available in the Al- Qassim area of the Saudi Arabia. The concentration of nineteen elements (Be, B, Al, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Mo, Ag, Cd, Sb, Ba, Sn, and Pb) on the bottled water samples were analyzed using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) followed by the standard procedure. The results obtained indicated that all of the elements except Boron in the bottled water were found within the permissible limits set by standards used.
Key words – Elements, Bottled water, Al- Qassim, ICP-OES.

Introduction

Water is the basic element of the living organisms, without it in a regular range, the body survival time is limited to a matter of days[1].The major natural resources of water include surface water (lakes, rivers, and streams) and groundwater (borehole and well water)[2,3]. Safe and good quality drinking water is of basic importance for human physiology, and it is the most essential need for good health [4,5]. The contamination of our environment is directly related to the contamination of the water bodies. In many parts of the world, inadequate access of the drinking water humans has used are sources which is contaminated with disease vectors, pathogens, unacceptable levels of toxins or suspended solids. In this context, the demand for bottled water in Saudi Arabia and other countries of the world, registered a significant increase due to the growing population and concern about contaminants in natural water supplies [6,7,8,9,10].

Heavy metals have become of particular interest in recent decades within the framework of environmental investigation. During the last decade, the development of Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) made it one of the most important contributors to the inorganic analytical chemistry. It has become a widely used and reliable technique for the analysis of water samples of different origin.

The metallic element that has relatively high density or, more precisely, a specific gravity greater than 5.0 is called heavy metals[11]. There are over 50 elements that can be classified as heavy metals and 17 of which are considered to be very toxic and relatively accessible[12]. Toxicity depends up on the type of the metal, and its biological role and type of the organisms, which is affected.Several metal ions such as sodium, potassium, magnesium, calcium and six other transition metals such as manganese, iron, cobalt, copper, zinc, and molybdenum were essential for optimal growth, development, reproduction and catalysts for enzymatic activity in human bodies; however excess level can cause severe toxicity[13]. The heavy metal in drinking water may cause series of health issues that include damaged or reduced mental and central nervous function as well lower energy level. Toxicity depends on the nature and quantity of the metal ingested. Cadmium is extremely toxic even in small concentrations, they will bio-accumulate in organisms and ecosystems. Long-term exposure of cadmium leads to renal damage[14] and exposure of maximum contamination level for relatively short period causes nausea, vomiting and diaarohea etc[15]. Excess copper leads to heamolytic anaemia, emotional problems, behavioral disorders, nephritis, and severe damage to the central nervous system[16,17]. High exposure of lead can cause irreversible brain damage and it is a possible human carcinogen. It has been linked to the development of autoimmunity causing joint diseases and ailments of the kidney, circulatory system[18]. In the case of chromium, chromium (VI) has found to be more dangerous. It increases the risk of lung cancer and that ingesting large amounts can cause upset stomach, ulcers, convulsions, kidney, liver damage, and even death[19,20].High concentrations of barium causes vasoconstriction by direct stimulation of arterial muscles, peristalsis by violent stimulation of smooth muscles, convulsions and paralysis by stimulation of the central nervous system[21]. Cobalt and nickel are reported to induce convulsion that cause break in DNA strand. It is also reported to be organ toxic[22,23,24]. Nickel may cause some morphological transformations in numerous cellular system causing chromosomal aberrations[25]. Molybdenium is an essential nutrient for life but high ingestion may be associated with potential mineral imbalance by increasing serum cruloplasmin and urinary extraction of copper. Some studies pointed out that arsenic may cause cardiovascular diseases, hypertension etc [26].

In Gulf, there is an overgrowth of the bottled drinking water business to cover the increasing demands of good drinking water quality. There is a concern of the quality of these bottled drinking waters. The aim of this work was to analyze the toxic metal characteristics of fourteen most popular bottled drinking water sold in the AL Qassim province of Saudi Arabia.

Materials and Methods

Water sample collection

A total of 14 most popular brands of bottled water used in Al Qassim region were purchased from independent food stores. The samples consisted of both the ground water and processed water. All bottles were made up of plastic and detailed information were mentioned in Table No.1

Table. No.1. Description of the samples

Sample No	Name	Bottle	Content as mentioned on the bottles in mg/L				
			pH	Fe	Na	Mg	Ca
1	Qatarat	PET 16 L	7	0.02	15	1.2	7.3
2	Shahd	PET 16 L	7	0.02	15	1.2	7.3
3	Salsabel	PET 16 L	7.4	0	29	1.2	7.4
4	Ramah	PET 250 ml	7.2	0.03	20	1.5	8
5	Qassim	PET 200 ml	7.4		29	1	8.4
6	Mattar	PET 250 ml	7.3	0.1	23	1.5	9
7	Deem	PET 330 ml	7.4	0.02	15	1.2	2.3
8	Hana	PET 600 ml	7.2		22	3	8
9	Fayha	PET 1.9 L	7	0.02	15	1.2	7.3
10	Haly	PET 330 ml	7.6	0.02	22	3	12
11	Ertawina	PET 330 ml	7.6	0.02	22	3	12
12	Manahel	PET 600 ml	7.4	0.02	28	3.7	12
13	Rabie qassim	PET 250 ml	7.3	0.1	23	1.5	9
14	Al Rayan	PET 1.9 L	7.1	0.01	28	1	2.2

Chemicals and reagents

High purity water (Specific resistivity 18 MΩ cm-I) obtained from a Thermo scientific water purification system was used throughout the work. A multi element standard (Fluka Analytical Trace CERT) containing 27 elements with certified concentration values was used as an external standard during the analysis.

Elements analysis

The analysis was performed by a Thermo Scientific ICP-OES spectrometer, type iCap6000 Duo, equipped with a standard torch, cross flow nebulizer and auto sampler. The typical instrument conditions and measurement parameters used throughout were listed in Table. No. 2.

Table No.2. Operating condition for ICP-MS

Description	Value
Nebulizer Gas Flow	0.65
RF Power	1150 W
Auxiliary Gas Flow	0.50
Flush Pump Rate	100
Analysis Pump Rate	50
Pump Stabilization Time	5
Pump Tubing Type	Tygon Orange/White

Quality assurance

To assess the analytical process and make comparative analysis, Standard Reference Material (SRM), Water spiked with trace Elements were analyzed in the same manner as all water samples. Table No. 3 compares the certified values and those obtained in this work by a quantitative method. The results were found generally in good agreement with the certified values.

Table.3. Reference material spiked with trace elements

Element	Recommended value	Result (ppm)	% RSD
Arsenic	0.5	0.4886	0.17
Cadmium	0.15	0.1519	0.14
Cobalt	0.12	0.113	0.77
Chromium	0.18	0.1692	0.317
Copper	0.14	0.1405	0.327
Iron	1.75	1.791	0.318
Manganese	0.1	0.1033	0.24
Lead	0.14	0.143	0.24
Selenium	0.12	0.1212	0.98
Zinc	0.14	0.1307	0.2

Results and Discussion

Table No. 4 shows the elemental concentration of nineteen elements of the samples under investigation. None of the elements exceed the SASO[27] (2003) bottled drinking water guideline, WHO[28] (2006), EU[29] (1998) and EPA[30] (2007) limits except Boron in some samples. The concentration of Boron in the water samples showed wide variations that ranged between 121 to 664.3 µg/L.The guideline value of 500 µg/L was designated as provisional because, with the treatment technology available, it will be difficult to achieve in areas with high natural boron levels. In this work, sample number 10 records the highest concentration, which is 664.3 µg/L.

Table.4. Concentration (µg/L) of the various elements of investigated bottled water brands from Al-Qassim region, Saudi Arabia

Element	1	2	3	4	5	6	7	8
Silver	ND	ND	ND	ND	ND	ND	ND	ND
Aluminium	ND	ND	ND	7.4	ND	ND	ND	ND
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND
Boron	434.5	542	646.9	650	415.7	327.8	293.9	309.4
Barium	2.67	1.55	1.75	2.07	2.41	7.84	2.42	2.16

Beryllium	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	ND	ND	ND	ND	ND	ND	ND	ND
Copper	ND	ND	ND	ND	ND	ND	ND	ND
Iron	ND	ND	ND	ND	ND	ND	ND	ND
Manganese	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND	ND	ND	ND
Lead	ND	2.32	1.33	ND	1	1.62	1.51	1.27
Antimony	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	ND	ND	ND	ND	ND	ND	ND	ND
Tin	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	11.47	ND	5.21	ND	ND	ND	5.45	ND

	9	**10**	**11**	**12**	**13**	**14**	**SASO**
Silver	ND	ND	ND	ND	ND	ND	100
Aluminium	ND	ND	ND	7.4	ND	ND	200
Arsenic	ND	ND	ND	ND	ND	ND	10
Boron	251.3	664.3	656.6	121.3	223.7	217.7	500
Barium	3.84	3.01	3.29	2.09	10.23	29.73	700
Beryllium	ND	ND	ND	ND	ND	ND	1
Cadmium	ND	ND	ND	ND	ND	ND	3
Cobalt	ND	ND	ND	ND	ND	ND	
Chromium	ND	1.02	1.2	ND	ND	ND	50
Copper	ND	ND	ND	ND	ND	ND	2000
Iron	ND	ND	ND	ND	ND	ND	300
Manganese	ND	ND	ND	ND	ND	ND	500
Molybdenum	ND	ND	ND	ND	ND	ND	70
Nickel	ND	ND	ND	ND	ND	ND	20
Lead	1.44	1.63	1.28	0.86	1.27	1.85	10
Antimony	ND	ND	ND	ND	ND	ND	5
Selenium	ND	ND	ND	ND	ND	ND	10

Lead concentration in most of the samples under investigation reported that the presence of trace amounts with a maximum value of 2.32, but well below the proposed SASO guideline value, which is 10 ppb. Lead is toxic to both the central and peripheral nervous systems, inducing sub encephalopathic neurological and behavioral effects. The IARC has classified lead and inorganic lead compounds in Group 2B (possible human carcinogen). Young children absorb 4-5 times as much lead as adults, and the biological half-time may be considerably longer in children than in adults The range of lead contamination in the present water was found lower than the studies reported in Italy[31], European countries[32] and in Iran[33]. The average lead concentration in this study was found higher than the studies of Guler and Alpaslan[34], Pehet al[35]. and Karmanis et al[36].

According to Guler and Alpslan (2009) the analysis of 70 samples of bottled water collected from Turkish market showed that the concentration of arsenic in one brand was three times more than the standard value set by European Community Council[29] and the guideline value recommended by World Health Organization [28]. Studies of Abdulrasoulet al[37] pointed out that Fluoride and Bromate level in the bottled water marketed in the Saudi Arabia was found higher than the permissible limits sets by standards used.

Conclusion

The study has showed that the bottled water sold in Al- Qassim region is of good quality with respect to the element concentration. In general, all elemental concentration is far below any threshold level reported for drinking water.

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