

Evaluation of Trace Metals Found in Bottled Waters Sold in Izmir Turkey

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Abstract

Within the scope of this work, 30 brands of bottled water sold in the Izmir Province of Turkey, were investigated for the levels of 6 trace metals (Al, Cr, Cu, As, Cd, and Pb) important for public health and drinking water quality. Inductively Coupled Plasma Mass Spectrometry (ICP-MS) was used for the analysis of the trace metals. The highest metal ion concentrations obtained in the analyses of the samples was found to be 102.99 $\mu\text{g Al/L}$, 1.80 $\mu\text{g Cr/L}$, 40.22 $\mu\text{g Cu/L}$, 11.36 $\mu\text{g As/L}$, 0.08 $\mu\text{g Cd/L}$, and 2.79 $\mu\text{g Pb/L}$. The concentration levels revealed in this work were compared to the maximum concentration levels allowed by the WHO and other international standards, and as a result, a water sample of one brand, from the natural waters of Izmir, contained a total arsenic level (11.36 $\mu\text{g As/L}$) exceeding national and international standards.

Keywords: Bottled water, trace metal (Al, Cr, Cu, As, Cd, Pb), inductively coupled plasma mass spectrometry (ICP-MS), Izmir (Turkey)

İzmir İlinde (Türkiye) Satışı Yapılan Şişe Sularının İz Metal Kalitesi Yönünden Değerlendirilmesi

Özet

Bu çalışma kapsamında, İzmir ilinde ticari olarak satışı yapılan 30 farklı markaya ait şişe suyu örneklerinde, insan sağlığı ve içme suyu kalitesi açısından önemli olan 6 iz elementin (Al, Cr, Cu, As, Cd ve Pb) total varlığı araştırılmıştır. İz metallerin analizinde indüktif olarak eşleştirilmiş plazma-kütle spektrometresi kullanılmıştır. Örneklerin yapılan analizleri sonucunda elde edilen en yüksek metal iyonu konsantrasyonları 102,99 $\mu\text{g Al/L}$, 1,80 $\mu\text{g Cr/L}$, 40,22 $\mu\text{g Cu/L}$, 11,36 $\mu\text{g As/L}$, 0,08 $\mu\text{g Cd/L}$ ve 2,79 $\mu\text{g Pb/L}$ olarak bulunmuştur. Elde edilen konsantrasyonların 98/83/EC, WHO ve ulusal standartlardaki maksimum konsantrasyonlarla karşılaştırılması sonucunda İzmir ilinde satışı yapılan doğal kaynak sularından bir markaya ait su örneğinde toplam arsenik miktarının (11,36 $\mu\text{g As L-1}$) ulusal ve uluslar arası limitleri aştığı belirlenmiştir.

Anahtar Kelimeler: Şişe suyu, iz metal (Al, Cr, Cu, As, Cd, Pb), indüktif olarak eşleştirilmiş plazma-kütle spektrometresi (ICP-MS), İzmir (Türkiye).

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INTRODUCTION

Water is the basic element of living organisms; without it, they cannot survive (Petraccia et al. 2006, Alemdar et al. 2009). Safe and good quality drinking water is the fundamental for good human health (Karavoltos et al. 2008, Krachler and Shotyk 2009). Drinking water plays a major role in the intake of some of valuable and toxic trace elements in humans (Nkono and Asubiojo 1997, Turk and Alp 2010). High trace metal concentrations in food and drinks can invoke serious health hazards in humans (Table 1). All essential trace metals become toxic when their concentration levels become excessive (Saleh et al. 2001).

The bottled water industry in Turkey is a very dynamic and competitive market, with key players focusing on natural spring water, which translates

into an industry with regional brands tied to local spring water sources (Güler 2007). Bottled spring water consumption is widespread amongst metropolitan people due to concerns about the quality of the tap water (Kavcar et al. 2009).

Potential sources of trace metals are varied. Origins of trace metals in water are given in Table 2 and the sources identified as (I) Natural processes, (II) Agricultural activities, (III) Human settlements, (IV) Industries (including industrial wastewater discharges), and (V) Production and distribution.

The concentrations of many trace metal ions in natural water samples are generally at the $\mu\text{g/L}$ level (Divrikli and Elçi 2002).

The purpose of this article was to investigate the trace metal characteristics of the domestic brands of bottled waters sold in Izmir and, along with this,

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selected parameters are compared with the action levels of the national and international standards.

MATERIAL AND METHODS

Sample Collection and Preparation

Thirty brands of bottled water were purchased randomly from supermarkets in Izmir. All bottled waters were in polyethylene terephthalate (PET) containers. The bottled water capacity of the samples purchased ranged between 0.5 and 5 L. The samples were purchased and analyzed between November 2009 and November 2010. To keep the brand names anonymous, the waters were given a numerical code from 1 to 30 and this convention was used throughout the study. The bottled waters were acidified with nitric acid (65% Suprapur Merck) to a pH<2.

Analytical Methodology

An inductively coupled plasma mass spectrometer (ICP/MS, Agilent 7700x) with auto sampler (Agilent ASX-500) was used for the analysis of the trace metals. The operating conditions for ICP-MS are shown in Table 3. Multi-element calibration solutions of all investigated elements were prepared daily by dilution of 10 mg/L stock standard solutions (Multi-Element Calibration Standard-2A, Agilent Technologies Part # 8500-6940). To insure accuracy, each sample was analyzed three times.

Quality Control

The accuracy of the analytical technique was evaluated by analyzing a certified Standard reference material (PT 2010-11, SEM).

RESULTS

The comparisons between the trace metal values obtained in this study with certified values for the reference material (PT 2010-11, SEM) are shown in Table 4.

Minimum, maximum, and mean values of trace metal concentrations present in the thirty bottled water samples sold in Izmir are shown in Figure 1.

The summary statistics, of the trace metals determined in the 30 brands of bottled water sold in Izmir, are detailed in Table 5 together with corresponding guidelines issued by the Republic of Turkey Ministry of Health (Anonymous 2005), the World Health Organization (Anonymous 2008), and the Council of the European Union (Anonymous 1998).

DISCUSSION

Aluminum: One sample of natural spring water

Table 1. Elements and their potential health hazards.

Element	Potential health hazards	References
Al	Alzheimer's disease	Flaten 2001, Rondeau 2000
Cr	Allergic dermatitis, cancer	Anonymous 2009, Davidson et al., 2004, Smith and Steinmaus 2009
Cu	Short-term exposure: Gastrointestinal distress. Long-term exposure: Liver or kidney damage; Wilson's disease	Anonymous 2009
As	Bladder cancer, lung cancer, cardiovascular disease, skin damage, problems with circulatory systems	Mink et al., 2008, Celik et al., 2008, Bošnjak et al., 2008, Ghosh et al., 2008
Cd	Kidney damage, testicular tumors, renal dysfunction, hypertension, arteriosclerosis, growth inhibition, chronic diseases of old age, and cancer	Anonymous 2009, Flick et al., 1971
Pb	Delays in physical or mental development in infants, slight deficits in attention span and learning abilities in children, kidney problems, high blood pressure, anemia, muscle paralysis	Anonymous 2009, Chen and Huang 2002

Table 2. Origins of trace metals in water.

Element	Origin					References
	I	II	III	IV	V	
Al	■					Bache 1986, Upadhyay et al. 2002
Cr	■			■	■	Sperling et al. 1992, Thompson et al. 2007, Owlad et al. 2009
Cu		■	■	■	■	Oliveira-Filho et al. 2009, Thompson et al. 2007
As	■			■		Bissen and Frimmel 2003, Thompson et al. 2007
Cd	■			■		Hutton 1983, Thompson et al. 2007, Naja and Volesky 2009
Pb	■			■	■	Thompson et al. 2007, Naja and Volesky 2009

Table 3. Operating conditions for ICP-MS.

Radio frequency power	1550 W
RF matching	2.1 V
Sample depth	8 mm
Carrier gas	0.85 L/min
Dilution gas	0.13 L/min
S/C temperature	2°C
Nebulizer type	MicroMist

Table 4. Concentration of the elements ($\mu\text{g/L}$) examined in this work and the Standard Reference Material (PT 2010-11, SEM).

Element	PT 2010-11		Found	
	Certified	Std dev	Value	Std dev
Al	43.57	13.63	36.92	6.09
Cr	19.18	3.25	18.91	0.96
Cu	59.08	5.23	62.85	2.33
As	10.98	1.10	11.14	0.54
Cd	9.36	1.04	9.11	0.26
Pb	11.47	2.23	11.39	0.23

Std dev: Standard deviation

contained 102.99 $\mu\text{g Al/L}$ aluminum, a lesser level than the 200 $\mu\text{g Al/L}$, allowed by Turkish and international guidelines. Comparison of the Turkish and international standards for the trace metal concentrations in drinking water is given in Table 5. In Table 6, maximum metal concentration levels obtained by certain researchers are presented. In an investigation by Birke et al. (2010) the maximum aluminum concentration was detected at 280 $\mu\text{g Al/L}$. This value exceeded the Turkish, European Union and WHO guidelines.

Chromium: The levels of chromium in the

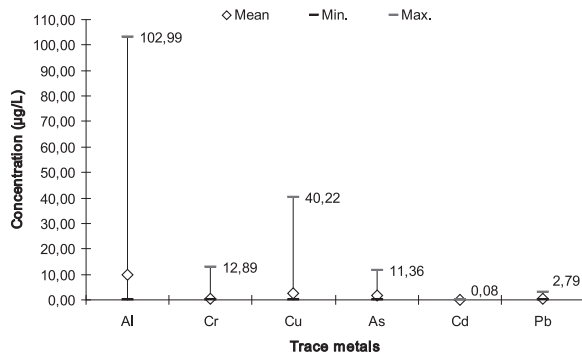


Fig 1. Minimum, maximum, and mean concentrations of the metals found in the bottled waters of this study.

natural spring water samples were low. When chromium concentrations are evaluated according to Table 6, the maximum chromium values obtained by research are below the levels allowed in national and international guidelines (50 µg Cr/L).

Copper: All samples contained less than the Turkish and international guidelines of 50 µg Cu/L. The highest copper level detected (170 µg Cu/L), in research, was carried out by Birke et al. (2010) in Germany and is much higher than the European Union and WHO standards.

Arsenic: Only one sample contained a total arsenic concentration (11.36 µg As/L) that exceeded the Turkish, European Union, and WHO guidelines. Güler and Alpaslan (2009) found a significantly higher level of arsenic (30.63 µg As/L) in their study.

Cadmium: Cadmium concentration in the tested samples was very low (0.01 – 0.08 µg Cd/L). In only one sample were Cadmium levels found to be at a threshold value (5 µg Cd/L) see Table 6 (Ikem et al. 2002).

Lead: None of the samples analyzed contained any levels higher than the recommended maximum

Table 5. Comparison of the Turkish and international standards for the trace metals concentrations in drinking water (µg/L).

Trace metal	Mean values	Maximum values $\pm$ se	Limit values		
			I	II	III
Al	9.70	102.99 $\pm$ 4.26	200	200	200
Cr	0.55	1.80 $\pm$ 0.45	50	50	50
Cu	2.41	40.22 $\pm$ 1.44	2000	2000	2000
As	1.72	11.36 $\pm$ 0.56	10	10	10
Cd	0.03	0.08 $\pm$ 0.00	5.0	3.0	5.0
Pb	0.25	2.79 $\pm$ 0.12	10	10	10

se: Standard error, I: Turkish guideline (Anonymous 2005), II: WHO Guidelines for drinking-water quality (Anonymous 2008), III: 98/83/EC (Anonymous 1998).

Table 6. Maximum concentrations of the trace metals in the investigated bottled waters and their comparison to data from the literature.

No	Maximum trace metal concentration (µg/L)						Literature
	Al	Cr	Cu	As	Cd	Pb	
1	102.99	1.80	40.22	11.36	0.08	2.79	This study
2	85.00	2.99	12.80	1.72	0.226	0.503	Björn et al., 2010
3	16.60	1.14	5.31	1.50	0.009	0.65	Peh et al., 2010
4	281	12.4	170	17.2	0.439	5.13	Birke et al., 2010
5	131.10	6.40	6.78	30.63	1.34	0.32	Güler and Alpaslan 2009
6	---	3.64	0.96	---	0.02	0.74	Karamanis et al., 2007
7	6.5	0.4	2	12	5	3	Ikem et al., 2002
8	---	12.8	10.54	---	1.36	---	Saleh and Doush 1998
9	---	2.17	5.33	---	1.13	1.27	Nkono and Asubiojo 1997

level of 10 µg Pb/L. When the work summarized in Table 6 is evaluated, the highest lead level (5.13 µg Pb/L) is seen to be below the national and international standards.

CONCLUSIONS

This study has showed that bottled water sold in Izmir is of good quality. In general, all elemental concentrations are far below any threshold levels reported for drinking water, except for total arsenic. A water sample belonging to a certain brand has been observed to present a total arsenic level exceeding national and international levels. Bottled water consumption is rapidly increasing in the world and in Turkey. This underlines the importance of maintaining regular physico-chemical and microbiological controls of water.

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