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Weather Effect on Migration of Some Elements from Bottle to the Drinking Water

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The effect of weather on the quality of bottled drinking water is investigated. The concentration of some inorganic metals is a restrictive factor for drinking water quality, generally as consequence of their effects on the health. This fact makes necessary its regulation and monitoring. Usually drinking water bottles made of polyethylene terephthalate. Antimony concentration present in the polyethylene terephthalate is in the range of 136-190 ppm. The migration of some elements from the bottle to the water and the effect of weather in this process was monitored using inductively coupled plasma mass spectrometer technique.

Key Words: Weather effect, Polyethylene terephthalate, Drinking water, Antimony.

INTRODUCTION

Drinking water of good quality is essential for human health and development. Pollutants such as pesticides, fertilizers, bacteria, toxic metals and other potentially harmful-not yet identified-environmental contaminants, may deteriorate the quality of drinking water in many regions of the world[1].

With growing concern about the quality of drinking water, *e.g.*, Pb and Cu contamination through the plumbing system[2-8], bottled waters are becoming increasingly popular worldwide. Italy ranks as the country with the greatest annual production (10 billion L/year) and consumption (151 L/per capita/year)[9]. While tap water intended for human consumption is controlled regularly for an extensive array of potential contaminants by certified authorities, bottled waters undergo less comprehensive testing and less frequently. Moreover, the legal guidelines established to regulate the quality of tap water generally do not apply to bottled waters. The potential risks from exposure to potentially harmful contaminants from drinking bottled water, therefore, are rather difficult to assess.

Two studies were published investigating contaminants from water bottled in polyethylene terephthalate. The first, by Barbara Pinto and Daniela Reali studied bottled mineral water[10]. The bottled water was passed through a process to extract and concentrate chemicals in the water. The concentrated extract was then fed to special-purpose yeasts, which react to compounds that mimic the activity of human estrogen. Estrogenic activity was found in all tested samples, though the authors suggest that the activity was low in most (90 %) of the samples.

TABLE-1
ELEMENTAL CONCENTRATION IN THE REFERENCE MATERIAL NIST-1640

Element	This work		Certified	
	Con. ppb	RSD (%)	Con. ppb	RSD (%)
Li	49.8	1.50	50.7	2.76
Be	36.4	4.95	34.94	1.17
B	264	8.60	301.1	2.03
Na	27800	0.34	29530	1.05
Mg	5800	0.50	5819	0.96
Al	47.4	0.32	52	2.88
K	899	0.93	994	2.72
Ca	6990	0.97	7045	1.26
V	11.9	1.16	12.99	2.85
Cr	37.1	0.45	38.6	4.15
Mn	117	0.46	121.5	0.91
Fe	35.2	15.65	34.3	4.66
Co	19	0.50	20.28	1.53
Ni	27	1.19	27.4	2.92
Cu	89.2	0.19	85.2	1.41
Zn	64.7	1.36	53.2	2.08
Ga	0.198	30.20	–	–
As	27.3	1.59	26.67	1.54
Se	23.7	3.95	21.96	2.32
Rb	2.22	1.65	2	1
Sr	108	0.40	124.2	0.56
Mo	43.5	2.04	46.75	0.56
Ag	6.48	0.39	7.62	3.28
Cd	21.9	2.14	22.79	4.21
Sb	12.6	2.85	13.79	1.46
Te	0.328	26.89	–	–
Ba	139	0.96	148	1.48
Tl	0.146	42.60	< 0.1*	
Pb	26.8	0.79	27.89	0.50
Bi	0.143	40.49	–	–
U	0.834	7.41	–	–

The second study was conducted by Martin Wagner and Jörg Oehlmann and examined glass, polyethylene terephthalate and multi-layer tetrapack (paperboard with plastic liners) containers of mineral water[11]. In addition to the yeast assay described by Barbara Pinto study[10], the scientists tested for estrogenic activity using a hormone-sensitive variety of snail. In the presence of estrogen-mimicking substances, these snails produce more offspring. Snails and a growth medium were introduced into empty glass and PET bottles. The snails raised in PET bottles produced significantly more offspring than snails raised in glass bottles, suggesting significant estrogenic activity deriving from the plastic itself. Snails raised in glass also produced slightly more offspring than those in control samples.

EXPERIMENTAL

High purity water (Specific resistivity 18 MΩ cm^{-1}) obtained from a Millipore Mili-Q water purification system was used throughout the work. A multi element standard (Merck-6) containing 30 elements with certified concentration values was used as an external standard during the analysis.

Samples: Samples were selected as the most popular brand of bottled drinking water in Riyadh, Saudi Arabia. All water bottles were made of ploye thylene terephthalate PET. Three brand names were chosen and stored in refrigerator, outdoor and indoor for three months, June, July and August. The purpose is to find out the effect of exposing the bottele to hot wether and to the sun heat.

Elemental analysis: The analysis is performed by a Perkin-Elmer Sciex Instruments multi-element ICP-MS spectrometer, type ELAN6100, equipped with a standard torch, cross flow nebulizer and Ni sampler and skimmer cones. The typical instrument conditions and measurement parameters used throughout are listed below:

Value	Description
1.000	Nebulizer Gas Flow
8.250	Lens Voltage
1100.000	ICP RF Power
-2000.000	Analog Stage Voltage
-6.500	AC Rod Offist

Quality assurance: To assess of the analytical process and make a comparative analysis, standard reference material (SRM), Nist-1640 natural water purchased from the National Institute of Standards and Technology (NIST) USA was analyzed in the same manner as all water samples. Table-1 compare the certified values and those obtained in this work. The results are generally in good agreement with the certified values.

RESULTS AND DISCUSSION

Consumers around the world spending hundreds or even thousands of dollars on bottled water, because they think it is healthier or safer than its counterpart from the tap. It is not. Tap water is safer and highly regulated and monitored[1,12].

In addition to being no purer than tap water and a big waste of money, the production and distribution of bottled water causes host of equity and environmental problems.

One of the problems with bottled water is the bottle its self. These bottles can cause major problems to the environment and to the person using them.

TABLE-2
CONCENTRATION OF ELEMENTS IN BOTTLED WATER STORED IN REFRIGERATOR, INDOOR AND OUTDOOR FOR THREE MONTHS

	Sample ID:N						Sample ID:H						Sample ID:Q					
	N2: Indoor		N5: In refrigerator		N6: Outdoor		H2: Indoor		H5:In refrigerator		H6:Outdoor		Q2:Indoor		Q5:In refrigerator		Q6:Outdoor	
	Value	RSD	Value	RSD	Value	RSD	Value	RSD	Value	RSD	Value	RSD	Value	RSD	Value	RSD	Value	RSD
Li	7.9	1.6	7.6	2.1	7.7	4.6	0.6	4	0.6	1.5	0.6	1.9	0.2	3.2	0.2	4.7	0.2	8.4
B	256	0.8	248	2.5	258	4.6	145	2	138	0.9	146	1.1	465	1.1	452	1.4	476	3
Mg	5.5	1.4	5.6	0.6	5.4	1.1	5.3	1	5.2	1.1	5.3	1.3	4.9	0.8	5	0.8	5.1	0.7
Al	2	2.3	2	6.8	2	3.3	2.7	12	1.7	4.4	2.2	6.8	3.3	7.1	1.2	6.8	4.3	5
Ca	13	2.1	12	2.1	12	1.1	9.8	2	9.3	2	9.8	0.1	11	2.8	11	0.5	11	0.9
ppm																		
V	0.8	1.6	0.8	0.7	0.8	1.4	1.8	2	1.7	0.9	1.8	1.4	0.9	1.7	0.8	3.3	0.9	1.8
Cr	1.2	3	1.2	–	1.3	4.1	0.7	19	0.6	2.7	0.7	5.9	1.1	2.5	1.2	4.4	1.2	2
Mn	0.1	–	BLD	–	0.1	5.6	0.2	2	0.2	1.4	0.2	1.4	0.1	4.2	BLD	–	0.1	41
Fe	4.4	–	2.1	–	6.9	6.2	0.2	–	0.2	–	0.2	–	2	–	1.3	11	2.8	14
Co	BLD	–	BLD	–	BLD	–	0.3	2	0.3	0.7	0.3	1.5	0	3.1	BLD		BLD	–
Ni	0.5	5.9	0.5	–	0.6	2.9	0.2	13	0.1	22	0.2	7	0.2	7.3	0.2	11	0.2	15
Cu	BLD	–	BLD	–	BLD	–	0.1	15	0.1	12	0.2	5.2	0.2	7.7	0.2	5.2	0.2	6.3
Zn	1.7	2.4	1.7	1.4	1.7	0.8	1.5	1	1.5	2.9	1.5	2.4	2.9	2.3	2.6	0.9	3	2.8
As	0.3	–	0.3	–	0.3	–	0.7	9	0.7	13	0.8	7.2	0.8	2.6	0.8	2.2	0.8	4.1
Se	0.5	–	0.4	–	0.7	–	0.5	7	0.6	8.5	0.6	4.9	1.1	13	1.1	16	1.1	9.1
Rb	5.7	1.1	5.3	1.3	5.2	1.4	0.8	4	0.7	2	0.8	1.7	1.5	0.4	1.4	0.9	1.5	2.4
Sr	2.4	1.3	2.4	0.5	2.3	1	191	2	182	0.6	190	1.2	2.1	0.8	2.2	0.7	2.2	0.7
Mo	0.2	1.7	0.2	3.1	0.2	3	0.2	5	0.2	2.3	0.3	61	0.2	2	0.2	4.5	0.2	3.1
Ba	1.4	3.1	1.3	1	1.3	2.9	3	1	2.9	1.3	3	0.7	1.8	3.5	1.7	1.5	1.8	1.4
U	0.2	3.3	0.2	2	0.2	4.5	BLD	–	BLD		BLD		1.2	1.2	1.2	0.6	1	1.8
Sb	0.2	4.3	0.1	7.1	0.2	2.9	0.2	2	0.1	2.3	0.2	2.8	0.2	1.9	0.1	2.7	0.2	2.9
Sn	BLD	–	BLD	–	BLD	–	BLD	–	BLD	–	BLD	–	BLD	–	BLD	–	BLD	–

When water is kept in bottles, some of the chemicals from plastic begin to leach into the water. A 2006 Canadian study found that when water bottles made of PETs had been stored for 6 months, a significant amount of antimony (a toxic element) was found in the water[12].

The concentration of the elements in the PET used for manufacturing water bottles can be found in many published references. Concentration in ppm of some elements in the PET as in reference[13] are: Mg < 6, Al 3, Ca < 2, V 0.005, Cr 0.58, Mn 0.18, Fe < 30, Co 11.3, Ni < 5, Cu 0.76, Zn < 1, As < 0.1, Se < 0.2, Rb < 1, Sr < 2, Mo < 1.5, Ba < 1, U < 0.4, Sb 257, Sn < 1. The concentration of antimony is very high 257 ppm.

In this work we have compared the remarkably concentration of element in three brands of bottled drinking water stored for three months June, July and August in three deferent places refrigerator, outdoor and indoor. The aim was to find out the weather effect on migration of some elements to the drinking water. Table-2 shows the results. It is clear that the concentration of elements in bottled stored outdoor is higher than that one stored in refrigerator or indoor. That means that the condition of storage is effecting the migration of elements from the bottle material to the water.

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REFERENCES

1. M. Krachler and W. Shtyk, *Sci. Total Environ*., **407**, 1089 (2009).
2. B.L. Gulson, A.J. Law, M.J. Korsch and K.J. Mizon, *Sci. Total Environ*., **144**, 279 (1994).
3. B.L. Gulson, J. Matt, A.M. Giblin, A. Sheehan and P. Mitchell, *Sci. Total Environ*., **205**, 271 (1997).
4. F. Pizarro, M. Olivares, R. Uauy, P. Contreras, A. Rebelo and V. Gidi, *Environ. Health Perspect*, **107**, 117 (1999).
5. F. Pizarro, M. Olivares, M. Araya, V. Gidi and R. Uauy, *Environ. Health Perspect*, **9**, 949 (2001).
6. F. Pizarro, M. Araya, M. Vasquez, G. Lagos, M. Olivares, M.A. Mendez, B. Leyton, A. Reyes, V. Letelier and R. Uauy, *Biol. Trace Elem. Res*., **116**, 131 (2007).
7. B. Zietz, J. Dassel de Vergara, S. Kevekordes and H. Dunkelberg, *Sci. Total Environ*., **275**, 19 (2001).
8. B.P. Zietz, H.H. Dieter, M. Lakomek, H. Schneider, B. Keßler-Gaedtke and H. Dunkelberg, *Sci. Total Environ*., **302**, 127 (2003).
9. A. Versari, G.P. Parpinello and S. Galassi, *J. Food Compos. Anal*., **15**, 251 (2002).
10. B. Pinto and D. Reali, *Int. J. Hygiene Environ. Health*, **212**, 228 (2009).
11. M. Wagner and J. Oehlman, *Environ. Sci. Pollut. Res*., **16**, 3 (2009).
12. Bottled Water a Fact Sheet from the Safe Drinking Water Foundation http://www.invasivespeciesinfo.gov/aquatics/ballast.shtml; http://www.epa.gov/owow/invasive_species; www.safewater.org
13. O. Al-Dayel, O. Al-Horayess, J. Hefne and A. Al-Durahim, *Res. J. Chem. Environ.*, **13**, 92 (2009).