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Evaluation of Heavy Metals Content in Local and Imported Bottled Drinking Water

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ABSTRACT

Bottled drinking water may subject to physical, chemical and biological contamination due to water resources, technical process, storage and marketing facilities. Heavy metals seem to be the most important pollutants of bottled drinking water for various reasons and these metals such as lead, chromium, cadmium, and others may have several public health impacts. The current study was designed to assess the bottled water content of several heavy metals such as Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn in 38 samples of local and imported bottled drinking water. Also other parameters such as pH, EC were examined. A total of 38 trade mark bottled drinking water of both locally produced and imported samples were collected from different Iraqi towns for the period November 2010 and June 2011. The results of all examined variables were within Iraqi standard of drinking water except for Mn, Pb, and Zn where they found in some local bottled water samples higher than those of Iraqi standard. Also some imported samples had Pb content greater than that of Iraqi standard. However, further chemical and biological tests were needed.

Keywords: Bottled drinking water, Heavy metals, Contamination, Local, Imported, Iraqi Standard

تقييم مستويات العناصر الثقيلة في مياه الشرب المعبأة المحلية و المستوردة

الخلاصة:

ان مياه الشرب المعبأة قد تتعرض للتلوث بأنواعه الفيزياوي ، الكيمياوي والبايولوجي اعتماد على نوع المياه المستخدمة وأليات الانتاج و الخزن والتسويق ويعد التلوث بالعناصر الثقيلة من أهم مظاهر تلوث المياه المعبأة لما تحمله من تأثيرات هامة على الصحة العامة.

لقد صممت الدراسة الحالية لاختبار مستويات عدد من العناصر الثقيلة في عينات مياه الشرب المعبأة المحلية و المستوردة اذ تم جمع 38 علامة تجارية من مدن العراق المختلفة للفترة من تشرين الثاني 2009 الى حزيران 2010.

تم قياس قيم الدالة الحامضية (pH) و التوصيل الكهربائي (Electrical conductivity) فضلا عن تحديد مستويات عناصر الكادميوم (Cd) ، الكروم (Cr) ، النحاس (Cu) ، الحديد (Fe) ، المنغنيز (Mn) النيكل (Ni) الرصاص (Pb) والخارصين (Zn).

اظهرت نتائج الدراسة ان جميع قيم المتغيرات تحت الدراسة كانت ضمن قيم المواصفة العراقية 1937 الخاصة لمياه الشرب باستثناء المنغنيز ، الرصاص و الخارصين حيث وجدت مستويات هذه العناصر في بعض العينات المحلية اعلى من مثيلاتها في قيم المواصفة العراقية . أما في حالة العينات المستوردة ، فقد اظهرت الدراسة ان تركيز الرصاص كان اكثر من ضعف التركيز المسموح به في المواصفة العراقية.

ان الحاجة قائمة لاجراء المزيد من الفحوصات و الاختبارات البايولوجية لتقييم مستويات تلوث مياه الشرب المعبأة بانواع من بكتريا وفيروسات الامراض الانتقالية وكذلك عدد من الاختبارات الكيمياوية لتشمل عناصر ثقيلة اخرى كالزرنيخ وعدد من المركبات العضوية المصنعة كالتولين و الزايلين وغيرالمصنعة كالميثان ثلاثي الهالوجين الذي يتحرر الى المياه جراء استخدام الكلور في عملية التعقيم فضلا عن المركبات الكيمياوية التي تستخدم في صناعة العبوات البلاستيكية مثل فثاليت (phthalate) ، الستارين (styrene) و البايزفينول (bisphenol) كما ان الفحص الاشعاعي ضروري لاهميته التأثيرية على الصحة العامة.

INTRODUCTION

Bottled drinking water industry becomes well known economic investment worldwide due to increasing public demands for several psychological and social needs. Many people do believe that bottled drinking water is much safer than tap water, others find such water is very easy to handle, storage, and use. Furthermore, other peoples particularly those suffering from health problems and those in special health care are in urgent need for such water.

Almost, all global countries have set their own water quality standards for municipal potable water [1-2] but not for those bottled water [3] as these countries varied where some found no need for these standards in case of municipal water [2-3] and others imposed special criteria for bottled drinking water [4].

Bottled drinking water varied according to the type of water used such as municipal, mineral, sparking and spring water. Also, there is healthy bottled water with fluoride to prevent teeth decay [3,5].

Significant scientific attention was made towards bottled water via examining physical, chemical and microbial contamination, and water quality standards [6-9]. Several studies were carried out for heavy metal and microbial pollution [10-14]. Other works have examined the possible contamination by radioactive materials [3, 15-16]. However, bottled drinking water was subjected to further studies to assess types and levels of carcinogenic substances such as trihalomethane [3] in addition to other organic compounds used in producing plastic bottle such as phthalate, styrene and adipate and others like toluene, xylene [3.17-19].

Long term exposure to such pollutants may cause various health impacts resulting various organic, physiological disorders and carcinogenic diseases [3,5,20] targeting different human organs, in addition to abortions and teratogenic [3].

The current study was designed to assess physical parameters such as pH and electric conductivity and evaluation of several heavy metals content such as chromium, nickel, lead, cadmium, ferrous, zinc, copper, and manganese using in 38 local and imported drinking bottled water brands collected from different parts of Iraq.

Materials and Methods

During the period between November 2010 and June 2011, samples of different sizes bottled were collected from local markets covering as possible as 38 commercial national and imported brands of drinking water particularly those within consuming validity. The study samples were 25 local and 13 imported makes (Table 1). Conductivity and pH were measured using portable measuring devices; while heavy metals content (Cd, Cu, Cr, Fe, Mn, Ni, Pb and Zn) were analyzed using Atomic absorption spectrophotometer (AAS 6200 Shimadzu) following methods outlined in the Standard Method for Examination of Water and Wastewater [21].

All obtained data were subjected to statistical analysis using SPSS version to determine low, high and mean values and standard deviation.

Table (1): Bottled drinking water samples collected from local markets

Sample type	Trade mark	Bottle size (L)	Producing country	Sample type	Trade mark	Bottle size (L)	Producingc ountry
Local	Mutahida	0.5	Iraq - Baghdad	local	Jaam	0.5	Iraq- Sulymani a
		20			Ryan	0.5	
	Furat	0.5			Jian	0.5	
	Abojbara	20			**Sirwa**n	0.5	
	Al-Wafeer	0.5			Rosh	0.5	
	Rashef	0.5			**Life**	0.5	Iraq- Dahock
	Sun Time	0.5		Importe d	Lemma	0.5	Saudi Arabia
	Al-Dwaliya	20			Azba	0.6	
	Nada	20			Maeen	0.5	
	Everest	0.5			Fyhae	0.5	
	Saiba	20			Hunny	0.35	
	Sulaf	20			Hana 1	0.5	
	Shirin	0.5			Hana 2	0.5	
	Thig'gag	20			Zain	0.5	
	Basma	20			Aquafena	0.6	
	Zerkae	0.5			Tania	0.6	
	Sawa	0.1	Iraq- Simawa		Juda	0.25	Kuwait
	Rabee'a	0.5	Iraq- Samerae		Rawthataen	0.3	
	Mina	0.5	Iraq- Kirkok		Refresh	0.5	

Results and Discussion

In fact, trading labels of all examined samples are shown certain information such as pH values and others. Nevertheless, these details are not true and the actual values are well above those shown in labels. Also, the labels are free from heavy metal content such as Cr, Cu, Mn, Ni, Pb, and Zn.

Table 2 includes mean values of pH, EC, Cd, Cr, Cu, Fe, Mn, Ni, Pb, and Zn in all local and imported bottled water samples including Iraqi bottled water standards [22].

The results of current study has shown that the mean of all examined variables were much lower than those of local samples.

For pH values, the mean was 7.08 ± 0.36 and 6.65 ± 0.38 for local and imported bottled water samples respectively and for mean electric conductivity data, they were found to be 0.317±0.1 µS/cm for local brands and 0.24±0.04 µS/cm for imported. All these values however are within Iraqi standards. In general imported bottled drinking water had values of both pH and EC much lower than those of local samples.

Table(2): Values of variables examined in local and imported bottled drinking water samples and appreciated Iraqi standards.

variable	Mean ± SD		Iraqi standard
	Local water samples	Imported water samples	
pH	7.08 ± 0.36	6.65± 0.38	6.5 –8.5
EC µS/cm	0.317± 0.10	0.24± 0.04	0.5 –1.0
Cd mg/l	0.00004± 0.0002	0.00003 ± 0.0001	0.01
Cr mg/l	ND.	ND	0.05
Cu mg/l	0.9291± 0.01	0.0221± 0.01	1.0
Cu mg/l	0.9291± 0.01	0.1176± 0.03	0.3
Fe mg/l	0.118± 0.04	0.0427± 0.031	0.03
Mn mg/l	0.056± 0.03	0.0022± 0.004	0.05
Ni mg/l	0.035± 0.01	0.075± 0.03	0.02
Pb mg/l	0.092± 0.04	0.00121± 0.002	0.05
Zn mg/l	0.0296± 0.06	6.65± 0.38	3.0

Regarding heavy metal contents of bottled drinking water samples, the heavy metals concentration under test were found to be much lower than those of Iraqi standards [22] except of Fe & Ni content. Also, Mn level was higher than National standrds in several local and imported water brands. Furthermore, imported bottled drinking water had mean heavy metals content almost half of those found in local samples.

Cadimium concentration was found at mean of $4\times10^{-5} \pm 2\times10^{-4}$ mg/l in local samples while was $3\times10^{-5} \pm 1\times10^{-4}$ mg/l in imported bottled water samples. In fact, all examined local samples were free of cadimium content except one trade brand (Shirin) which had a level of 1×10^{-4} mg/l and same finding for imported water with exception of two samples (Tania an Refresh) which had a mean of 1×10^{-4} mg/l and 3×10^{-4} mg/l respectively.

For chromium content, the current results have shown that all examined local and imported samples were free chromium content (Table 2).

In case of copper water content, the obtained data shows that local produced bottled water had a mean of 0.0291 ± 0.01 mg/l and imported water samples had a mean of 0.0221 ± 0.01 mg/l. However, Cu values in local samples were ranged from 0.0103 mg/l in Furat water brand to 0.0487 mg/l in Rosh brand. In imported bottled water, this content was found to extend from 0.0082 mg/l to 0.0473 mg/l in Rawthataen and Tania brands respectively.

The mean level of Fe content in all tested water samples was found to be amost the same for both local and imported brands recording a mean of 0.118 ± 0.04 mg/l in local

samples and 0.1176 ± 0.03 mg/l in imported bottled water. These values, however were higher than that (0.03 mg/l) of Iraqi standards.

The study has found that Mn content in several water samples of local brands had exeded the National Iraqi standrds (Table 2), but over all Mn mean was 0.056 ± 0.03 mg/l was recorded in local samples and 0022. ± 0.004 mg/l was detected in imported samples.
It has been found that more than 60% of local brands and about 31% of imported water samples had Mn content higher than that of Iraqi standrds, where such vales were detected in water samples of Furat, Mutahida, Abo'jbara, Al-Wafeer, Mina and Jian and only one water sample (Ryain) was Mn free. In case of imported water brands, the water bottled brands of Hana 2, Aquafena, Refrest, and Tania had a mean of Mn higher than that of National standards.

Regarding nickel water content, the study has found that local water sampels had nickel concentration ranging from 0.023 mg/l in Everest water brand to 0.0372 mg/l in Bas'ma water sample. Nevertheless, many produced bottled water such as Furat, Mutahida, Al-Wafeer, Rashef, Sun Time, Sawa, Mina, Jaam, Ryan, Jian and Life were nickel free.
By contrast, nickel content was found in more than 38% of examined imported water brands such as Azba, Zain, Tania, Refresh and Rawthataen recording values ranging from 0.0011 mg/l to 0.0095 mg/l in Azba and Tania respectively.

In general, the mean Ni content was 0.035 ± 0.004 mg/l in locally produced brands and 0.075 ± 0.01 mg/l in imported water brands.

Regarding water lead content, the study had found similar results to those of manganese where some of local and imported water samples had lead concentration higher than that of Iraqi standards and more than 95 % of local water brands were found to have various lead content but only about 50 % have exceeded the National standards and only one local water brand (Life) was lead free. However, Pb content in local samples varied from 0.0134 mg/l in Nada water sample to 0.0213 mg/l in Jaam brand.
For imported water brands, the Pb content was ranged from 0.0051 to 0.1089 mg/l in Azba and Hana1 samples respectively. The later water brand (Hana1) was only the sample had Pb content higher the Standards.

The current study has shown that the mean of 0.092 ± 0.04 mg/l was detected in local sample and imported water samples had a mean of 0.075 ± 0.03 mg/l.

For water zinc content, the study has shown that both local and imported water samples had concentrations much lower than the national standard. Among local brands, only Furat water bottle was totally zinc free, but the others had Zn concentration varying from 0.0012 mg/l in Sun time water sample to 0.2934 mg/l in Saiba water brand. For imported bottled water, the study has found that less than 40% of examined samples had zinc content ranging from 0.0006 mg/l in brand Hana2 to 0.0075 mg/l in Al-Fyhae sample. However, mean zinc content in locally produced brands was 0.0296 ± 0.06 mg/l and 0.00121 ± 0.002 mg/l was found in case of imported samples.

In similar study [23], in which several local and imported bottled drinking water samples were tested and reported similar findings but some trading brands had copper and lead content higher than national standards and such data was justified to be due to probable leach of these metals during production stages from pipe lines.

The levels of heavy metals in bottled drinking water would be relay upon the raw water used and in general such water often municipal which is taken from surface water such as rivers, but some factories may use well water.

Surface waters may contain certain heavy metals at appreciated levels since some of these heavy metals are naturally and artificially emitted. Various studies that examined surface water have reported the presence of heavy metals at elevated levels [3,23] and the same findings in spring waters [3,23]. Also municipal pipeline nets may be behind heavy metals leaching that enhanced concentrations of these metals as it has been reported by previous study [23].

According to this study, it may seem difficult to recommend consuming any of these brands under test due to several reasons such as bacterial and viral contamination and other organic compounds such as phthalate, styrene and adipate and others like toluene, xylene [3,17] and phenol bies. Also, the accumulation feature of such pollutants may threat the safely of such water.

References

[1]. WHO (1984). Guidelines for Drinking Water Quality, vol. II .Health Criteria and other Supporting Information. Geneva.

[2] .USEPA (1998). Providing Safe Drinking Water in America. Safe Drinking Water Act Amendments, Executive summary .www.epa.gov/ogwdw.

[3] .NRDC (1999). Bottled Water: Pure Drink or Pure Hype. A Report to the Food and Drug Administration, www.nrdc.org/ndrcpro/bw/bwinx.html.

[4] .Allen, L. & Darby, J.L. (1994). Quality Control of Bottled and Vended Water in California. A Review and Comparison of Tap Water, J. of Environ. Health, Vol. 56, No. 8, pp 17-22.

[5] .Morris, R.D., A M Audet, I. F., Angelillo, T. C., Chalmers, and F. Mosteller (1992). Chlorination by Products and Cancer: a Meta Analysis, American J of Public Health, Vol. 82, No.7, pp. 955-963.

[6] .Hunter, P.R. & Burge, S.H. (1987). The Bacteriological Quality of Bottled Natural Mineral Water, Epidemiol. Infect, Vol. 99, No. 2, pp. 439-443.

[7] .Ikem, A., Odueyungbo, S., Egiebor, N.O. & Nyavor, K. (2001). Chemical Quality of Bottled Waters from Three Cities in Eastern Alabama, The Science of the Total Environment, Vol. 285, No. 1-3, pp. 165-175.

[8] .Warbuton, D.W. (1993). A Review of the Microbiology Quality of Bottled Water Sold in Canada. Part 2: The Need for More Stringent and Regulations, Canadian J. of Microbiology, Vol. 39, No. 2, pp. 158-168.

[9] .Warbuton, D., Harrison, C., Crawford, P., Foster, C., Gour, L. & Krol, P. (1998). A Further Review of the Microbiology Quality of Bottled Water Sold in Canada. 1992-1997 Survey Results, Int .J. of Food Microbiol., Vol. 39, No. 3, 221-226.

[10]. Lauwerys, R.R. (1979). Health Effects of Cadmium, In. Trace Metals Exposure and Health Effects, Di Ferante, E. Oxford Pergamon press.

[11] .Meranger, J.C., Subramanian, K.S. & Chalifoux, C. (1979). A National Survey for Cadmium, Chromium, Copper, Lead, Zinc, Calcium and Magnesium in Canadian Drinking Water Supplies, Environ. Sci. Technol. Vol. 13, No. 6, pp. 707-711.

[12] .Nkono, N. A. & Asubiojo, O. I. (1997). Trace Elements in Bottled and Soft Drinks in Nigeria- a Preliminary Study, The Science of the Total Environment, Vol. 208, No. 3, pp. 161-163.
[13] .Nsanze, H., Babarinde, Z. & Kohaly, A. (1999). Microbiological Quality of Bottled Drinking Water in the UAE and the Effect of Storage at Different Temperatures, Environ. Int., Vol. 25, No. 1, pp. 53-57.
[14] .Warburton, D.W., Bowen, B. & Konkle, A. (1994). The Survival and Recovery of Pseudomonas aeruginosa and its Effect Upon Salmonellae in Water: Methodology to Test Bottled Water in Canada, Can. J. Microbiol., Vol. 40, No. 12, pp. 987-992.
[15] .Lalumandier, J.A., Ayers, L.W. (2000). Fluoride and Bacterial Content of Bottled Water vs Tap Water, Archives of Family Medicine, Vol. 9, No. 3, pp. 246-250.
[16] .Copper,M.B.Ralph,B.J.&Wilks,M.J.(1982).Natural Radioactivity in Bottled Mineral Water Available in Australia, Government Reports Announcements and Index 21.
[17] .McCurdy, D.E. & Mellor, R.A. (1981). The Concentration of ^{226}Ra and ^{228}Ra in Domestic and Imported Bottled Waters, Health Phys., Vol. 40, No. 2, pp. 250-253.
[18] .Fayad, N.M., Sheikheldin, S.Y., Al-Malak, M.H., El-Mubarak, A.H. & Khaja, N. (1997). Migration of Vinyl Chloride Monomer (VCM) and Additives into PVC Bottled Drinking Water, Journal of Environmental Science and Health, Vol. 32, No. 4, pp. 1065-1083.
[19] .Ashby, R. (1988). Migration from Polyethylene Terephthalate under All Conditions of Use, Food Additives & Contaminants, Vol. 5, No. 1, pp. 485-492.
[20] .Yang, C.Y., Cheng, M.F., Tsai, S.S. & Hsieh, Y.L. (1998). Calcium, Magnesium and Nitrate in Drinking Water and Gastric Cancer Mortality, Jpn. J. Cancer Research, Vol. 89, No. 2, pp. 124-130.
[21] .American Public Association, American Water Works Association and World Environment Federation (2005). Standard Methods for Examination of Water and Wastewater, 21st Edition, American Public Association, Washington DC.
[22] .Iraqi Water Quality Control Center (1995). IQS 1937/1995 for Bottled Drinking Water.
[23] .Zahid, W.M.K. (2002). Quality of Local and Imported Bottled Water in Saudi Arabia, J King Abdel-Aziz for Engineering Science, Vol. 14, No.2, pp. 81-104.