American-Eurasian J. Agric. & Environ. Sci., 11 (3): 341-345, 2011
ISSN 1818-6769


# Evaluation of Bacterial Quality and Trace Elements Concentrations in 25 Brands of Iranian Bottled Drinking Water

[1]*Mohammad Bagher Miranzadeh,*
[1]*Mojtaba Ehsanifar and* [1]*Leila Iranshahi*

[1]Department of Environmental Health Engineering,
Faculty of Health,
Kashan University of Medical Sciences, Iran

**Abstract:** Twenty-five brands of Iranian bottled water were analyzed for microbial quality and trace elements. Obtained results were compared with Iranian, WHO and USEPA drinking water standards. All sample showed negative growth for total and fecal coliforms but in two brands results revealed positive growth for heterotrophic plate count (HPC) at 37°C but mean concentration of HPC in two brands fell below Iranian and WHO guidelines for drinking water (100cfu/ml). The mean concentration of Ni, Cd, Cr, Cu, Zn, Pb and Ag were lower than Iranian, WHO and USEPA drinking water standards and is safe for human consumption.

**Key words:** Bottled water · Trace elements · Microbial quality · Drinking water · Iran

## INTRODUCTION

The consumption of bottled water is rapidly rising in most countries especially in Iran. The increased demand for this water is attributed largely to factors such as inadequate safe drinking water in distribution network. Bottled water is defined as water that is intended for human consumption and that is sealed in Polyethylene terephthalate (PET) bottles with no addition of ingredient except it may contain disinfectants [1-3]. Bottled water is also utilized in emergency situation such as drought, earthquake, flood, hurricane and war which can damage public water supplies for long periods of time [4, 5]. The popularity of bottled water can be gauged by the number of brands produced in Iran (over 100). The source of bottled water sold in Iran is from springs, wells and tap water with desalination process and UV disinfection. Water borne diseases continue to be one of the major health hazards especially in developing countries. The high prevalence of diseases such as diarrhea, cholera, typhoid and paratyphoid fever, bacillary and amoebic dysentery among the population has been attributed to the consumption of unsafe drinking water [1, 2, 6, 7]. Therefore, its quality control is of great importance to consumer health. In addition to microbial contamination, presence of trace elements in bottled water can be hazardous to human health [8, 9]. Trace elements can be categorized into those essential to human life such as Co, Cr, Cu, Fe, Mn, Mo, Se and Zn and those potentially toxic, like Ag, Al, As, cd, Pb and Ni. Also, certain essential trace elements can be toxic when concentrations are raised above specific cut- off levels [8-10]. The consumption of bottled water with high concentration of trace elements can lead to a wide range of health problem and have carcinogenic, mutagenic and teratogenic properties [2, 8, 9]. To avoid potential health hazard caused by contaminated drinking water, Iran has set regulations for maximum allowable levels of these elements in drinking, bottled and mineral water [11-13]. International standards have also been set by WHO and USEPA, [14, 15].

This study therefore aims to provide information as to the safety of bottled drinking water marketed in selected area in Iran by determining microbial quality and the trace elements concentrations of several brands and comparison with Iranian and WHO drinking water standards.

**Corresponding Author:** Mohammad Bagher Miranzadeh, Kashan University of Medical Sciences, Iran.
Tel: +983615558430,

## MATERIAL AND METHODS

A total of 75 bottled water samples (3 samples for each brands) were analyzed for total coli form (TC), fecal coliform (FC) and heterotrophic plate count (HPC) and for total concentrations of 7 trace elements including Ag, Cd, Cr, Pb, Cu, Zn and Ni. Bottled water samples were purchased in polyethylene terephthalate containers with 1.5 Liter capacity during spring to autumn 2010 from the randomly selected supermarkets throughout Iran (one sample for each brand in each season). For TC and FC multiple-tube fermentation procedure was used and for HPC pour plates methods at 37°C. All analysis for trace elements were conducted by the inductively coupled plasma (ICP model optima 2100 Perkin Elmer) technique in Chemical Lab., Faculty of Health in Kashan University of Medical Sciences. Three replicates were read for each sample analyzed and their mean value was taken into account for assessment. It is noted that all the analytical tests were performed in accordance with the standard methods for the examination of water and wastewater [16].Because of doing ethics in research the trade name of bottled water weren't written, so, 25 brands of bottled water defined as $BW_1$ to $BW_{25}$ in text.

## RESULTS AND DISCUSSION

Table 1 showed the bacterial quality of 25 brands of Iranian bottled drinking water regarding to total coliform, fecal coliform bacteria and HPC. This table showed that TC and FC were not found in any of brands analyzed but HPC was found in two brands. The HPC concentration ranged between 10 to 84 cfu/ml in $BW_8$ brand and 4 to 69 cfu/ml in $BW_{13}$ brand. Geometric mean HPC counts varied from the lowest in $BW_{13}$ (31.5 cfu/ml) to the highest in $BW_8$ (47.5 cfu/ml). Results of this study showed that in 25 brands of the bottled drinking water sold in various region of Iran exhibited stable characteristics in term of the bacterioloigcal quality. All 25 brands of bottled drinking water studied were not contaminated with coliform bacteria and meet the Iranian and WHO drinking water standard of zero coliform per 100 ml water making them suitable for human consumption [12, 17-20]. Although, 6.5% (n=2) of the brands revealed positive results for HPC but geometric mean HPC concentration were compatible with Iranian standard (HPC<500 cfu/ml) and European community standard of maximum 100 HPC per milliliter of bottled drinking water [3,21,22]. According to WHO 2002 report a high HPC concentration does not itself present a risk to human health. Nevertheless HPC are used as good indicators of the overall quality of production. In bottled water such bacteria may be indigenous from the natural Source of the water or may be introduced during processing [14, 23]. It has also been established that a number of these bacteria could multiply during storage to reach infective doses [2, 4]. Results of another study on bottled water in Iran do not show the microbial contamination and all brands were compatible with national and international drinking water standard [1, 2, 6, 24, 25].

In Nigeria, a study on 16 brands of Bottled water revealed varying microbiological quality and a brand showed positive growth for fecal coliform bacteria [26]. In Lebanon, 32 brands of domestic bottled water were analyzed for microbial quality and results showed that in all sample growth for fecal coliform were negative, but 18.8% and 59.4% of the samples revealed positive result for total coli form and HPC at 37°Crespectively [5].

The results of measurement of Cr, Cd, Pb, Ni, Cu, Zn and Ag in 25 brands of Iranian bottled water are shown in table 2. The majority of elements were found as part per billion (PPb) level, so all values are reported as $\mu g l^{-1}$. Measured concentration of interest elements were compared with the maximum concentration level(MCL) regulated by Iranian, WHO and USEPA guidelines for drinking water as shown in table 3 [14,15,17,18,19].Results of our study showed that Iranian bottled waters are very different in characteristics and display a wide range of trace elements values. The ranges of values for the trace elements were: 0.1 to 1.92 for Ni; 0.11 to 10.7 for Pb; 0.15 to 3.71 for cu; 0.34 to 2.27 for zn; 0.12 to 3.15 for cr; 0.1 to 6.6 for cd and 0.03 to 1.25 for Ag as $\mu g l^{-1}$.

Table 1: Bacterial quality analysis of 25 brands of Iranian bottled drinking water during 2010

| Parameter | Total sample | Positive sample (number) | Negative sample (number) |
|---|---|---|---|
| Total coliform | 75 | 0 | 75 |
| Fecal coliform | 75 | 0 | 75 |
| Heterotrophic Plate count | 75 | 6 | 69 |

Table 2: Trace elements analysis for 25 brands of Iranian bottled water drinking during 2010 (values as $\mu gl^{-1}$)

| | | Nickel | | Lead | | copper | | zinc | | chromium | | cadmium | | silver | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brand | No-of sample | Mean | S.D | Mean | S.D | Mean | S.D | Mean | S.D | Mean | S.D | Mean | S.D | Mean | S.D |
| $BW_1$ | 3 | 0.79 | 0.21 | 3.5 | 0.3 | 1.1 | 0.21 | 1.2 | 0.18 | 0.98 | 0.11 | 1.7 | 0.88 | 0.52 | 0.18 |
| $BW_2$ | 3 | 0.87 | 0.41 | 2.2 | 0.16 | 1.3 | 0.2 | 0.91 | 0.12 | 1.5 | 0.4 | 1.03 | 0.7 | 0.51 | 0.2 |
| $BW_3$ | 3 | 0.22 | 0.12 | 1.91 | 0.42 | 2.2 | 0.8 | 1.71 | 0.3 | 1.46 | 0.31 | 1.34 | 0.81 | 0.22 | 0.15 |
| $BW_4$ | 3 | N.D | N.D | N.D | N.D | 0.66 | 0.4 | 0.94 | 0.13 | 2.3 | 0.49 | N.D | N.D | 0.35 | 0.15 |
| $BW_5$ | 3 | 0.75 | 0.3 | 1.26 | 0.29 | 0.36 | 0.1 | 0.95 | 0.19 | 1.6 | 0.61 | 1.79 | 0.4 | N.D | N.D |
| $BW_6$ | 3 | 0.45 | 0.32 | 2.3 | 1.2 | 0.3 | 0.88 | 0.76 | 0.3 | 2.02 | 0.3 | 1.19 | 0.29 | N.D | N.D |
| $BW_7$ | 3 | N.D | N.D | 0.8 | 0.1 | N.D | N.D | 1.3 | 0.41 | 0.7 | 0.32 | 0.78 | 0.5 | 0.3 | 0.12 |
| $BW_8$ | 3 | N.D | N.D | 1.7 | 0.17 | 0.8 | 0.51 | 1.46 | 0.36 | 0.78 | 0.13 | 1.31 | 0.42 | N.D | N.D |
| $BW_9$ | 3 | 0.61 | 0.17 | N.D | N.D | 1.65 | 0.41 | 0.97 | 0.48 | 0.8 | 11 | 2.41 | 0.9 | 0.55 | 0.12 |
| $BW_{10}$ | 3 | 1.41 | 0.36 | 1.15 | 0.82 | 2.41 | 0.7 | 1.13 | 0.52 | 2.1 | 0.33 | 1.31 | 0.3 | 0.45 | 0.14 |
| $BW_{11}$ | 3 | N.D | N.D | 0.6 | 0.12 | 1.65 | 0.49 | 1.36 | 0.39 | 0.78 | 0.26 | N.D | N.D | N.D | N.D |
| $BW_{12}$ | 3 | N.D | N.D | 0.22 | 0.16 | 1.52 | 0.79 | 0.67 | 0.31 | 0.9 | 0.14 | 1.1 | 0.45 | 0.7 | 0.21 |
| $BW_{13}$ | 3 | 0.77 | 0.31 | N.D | N.D | 0.81 | 0.28 | 0.82 | 0.05 | 0.92 | 0.37 | 0.3 | 0.12 | N.D | N.D |
| $BW_{14}$ | 3 | 1 | 0.15 | N.D | N.D | 0.81 | 0.21 | 1.05 | 0.31 | 1.25 | 0.4 | 0.31 | 0.1 | N.D | N.D |
| $BW_{15}$ | 3 | 0.87 | 0.23 | 0.53 | 0.14 | 0.73 | 0.12 | 0.94 | 0.26 | 0.29 | 0.19 | N.D | N.D | 0.6 | 0.13 |
| $BW_{16}$ | 3 | N.D | N.D | 2.1 | 0.31 | 1.4 | 0.31 | 0.7 | 0.2 | 0.89 | 0.13 | 1.51 | 0.72 | 0.61 | 0.11 |
| $BW_{17}$ | 3 | 0.61 | 0.14 | 1.3 | 0.17 | 1.16 | 0.21 | 0.72 | 0.17 | 1.2 | 0.21 | 1.14 | 0.62 | 0.51 | 0.18 |
| $BW_{18}$ | 3 | 0.37 | 0.16 | 1.75 | 0.39 | 2.05 | 0.61 | N.D | N.D | N.D | N.D | 0.75 | 0.31 | 0.57 | 0.21 |
| $BW_{19}$ | 3 | 0.72 | 0.15 | 0.76 | 0.32 | 0.82 | 0.42 | 0.92 | 0.31 | 0.6 | 0.22 | N.D | N.D | 0.67 | 0.32 |
| $BW_{20}$ | 3 | 0.56 | 0.18 | 0.95 | 0.31 | N.D | N.D | 1.2 | 0.37 | 0.67 | 0.14 | N.D | N.D | 0.81 | 0.17 |
| $BW_{21}$ | 3 | 0.78 | 0.2 | 1.31 | 0.26 | 0.87 | 0.37 | 0.85 | 0.32 | N.D | N.D | 0.3 | 0.1 | 0.66 | 0.12 |
| $BW_{22}$ | 3 | N.D | N.D | 0.79 | 0.33 | 0.5 | 0.16 | 0.76 | 0.27 | 0.6 | 0.1 | 0.78 | 0.22 | N.D | N.D |
| $BW_{23}$ | 3 | 0.5 | 0.17 | 1.32 | 0.29 | N.D | N.D | 0.86 | 0.25 | N.D | N.D | 0.62 | 0.31 | N.D | N.D |
| $BW_{24}$ | 3 | 0.68 | 0.13 | 1.27 | 0.36 | 0.72 | 0.29 | 1.6 | 0.37 | 0.87 | 0.2 | 0.97 | 0.2 | 0.37 | 0.15 |
| $BW_{25}$ | 3 | N.D | N.D | 0.89 | 0.23 | 0.67 | 0.21 | 0.96 | 0.32 | 0.73 | 0.21 | 0.98 | 0.19 | 0.49 | 0.14 |

- N.D= Not Detectable

Table 3: Maximum permissible level of trace elements in drinking water ($\mu gl^{-1}$)

| NO. | trace element | as | Iranian national standard | WHO guidelines | USEPAStandard |
|---|---|---|---|---|---|
| 1 | Silver | Ag | - | - | 16 |
| 2 | Cadmium | Cd | 3 | 3 | 5 |
| 3 | Chromium | Cr | 50 | 50 | 100 |
| 4 | Copper | Cu | 1000 | 2000 | 1000 |
| 5 | Zinc | Zn | 3000 | - | 5000 |
| 6 | Lead | Pb | 5 | 10 | 15 |
| 7 | Nickel | Ni | 20 | 20 | - |

Based on findings of this study in all sample of analyzed bottled water the concentration of seven trace elements were well below Iranian, WHO and USEPA standard for drinking water. This is probably because of the utilization of reverse osmosis (RO) process for production of the most bottled water in Iran. RO process is very efficient for removal of trace elements and other minerals [6, 7, 24, 27]. Another study on bottled water in Iran showed that mean concentration of mentioned trace elements were lower than Iranian, WHO and USEPA standard which is compatible with our study findings [2, 6].

A study on some brands of bottled water in Menitoba, Canada showed that concentration of lead and cadmium were higher than Canadian water quality guidelines for drinking water. This is probably because of differences in water source, handling and type of packaging and cadmium-based stabilizer in plastic among the brands [21].

Another studies in Greece, Turkey, Croatia, India and Kuwait on different brands of bottled water quality have been showed that concentration of trace elements in all samples were well within WHO and USEPA standard and were compatible with our study results in Iran [5, 21, 28-33].

In conclusion, this study covers a limited number of bottled water marketed in Iran and it is recommended that all sold of bottled water be monitored for bacteriological and chemical quality by concerned authorities. However, in analyzed bottled water microbial quality (Total coliform and fecal coliform) and trace elements concentration were within the Iranian, WHO and USEPA guidelines for drinking water.

## ACKNOWLEDGEMENT

The financial support of research Department of Kashan University of Medical Sciences gratefully acknowledged.

## REFERENCES

1. Samadi, M.T., A.R. Rahmani and M. Sedehi, 2009. Evaluation of chemical quality in 17 brands of Iranian Bottled water. J. Res. Health Sci., 9(2): 25-31.
2. Ghaderipoor, M., 2009. Determination of toxic trace element in Bottled Waters Consumption in the of Tehran; 12 th National Congress on Environmental Health, Tehran-Iran.
3. Arve misuned, 1999. Variation of 66 elements in European bottled mineral waters; The Science of total Environment, 243-244: 21-41.
4. Guler, C. And M. Alpaslan, 2009. Mineral content of 70 bottled water brands sold on the Turkish market. Journal of Food Composion and Analysis, 22: 728- 737.
5. Lucy, A. Semerjian, 2010. Quality assessment of various bottled waters marketed in Lebanon. Environ Monit Assess. DOI: 10. 1007/s 10661-010-1333-7, speringer.
6. Forouzan, Sh., 2008. Study of Heavy metals, Nitrite, Nitrate and Microbial Properties of Waters Markets of west Azerbaijan; 18 th National Congress on Food Technology, Mashhad-Iran, pp: 15-16.
7. Salvato, J., 2003. Environmental Engineering Sanitation. 5thEd., John Wiley and Sons, Washington DC.
8. Sanai, Gh. H., 2006. Industrial Toxicology, Vol. 1, 7th Revision, University of Tehran Press. Iran.
9. Berlin, M., 1985. Handbook of the Toxicology of Metals, V.2, 2nd ed. London, Elsevier Science Publishers B.V., pp: 376-405.
10. Massaro, Edward J., 1997. Handbook of Human Toxicology, National Health and Environmental Effects Research Laboratory, CRCPress, Boca Raton, New York.
11. Institute of standards and industrial Research of Iran, 2002. Water- Microbiological Specifical of Packaged Drinking Water. ISIRI Number 6267, 1st Edition, Available at: www.isiri.org.
12. Institute of Standards and Industrial Research of Iran, 2010. Drinking Water -Physical and Chemical Specifications; ISIRI Number 1053, 5th revision. Available at: www.isiri.org.
13. Institute of standards and industrial Research of Iran, 2002. Code of Hygienic Practice For Packaged Drinking Water; ISIRI Number 6305, 1st Revision. Available at: www.isiri.org.
14. WHO., 2004. Guideline Values for Drinking Water Quality. 3rd Ed.: World Health Organization Geneva.
15. EPA. 2003. Drinking water standard. Washington DC: Office of Drinking Water, US Environmental Protection Agency, USA.
16. American Public Health Association (APHA), 2005. Standard Method for the Examination of Water and Wastewater, 21th Ed, Washington DC. USA.
17. Institute of standards and industrial Research of Iran, 2001. water-packaged (bottled) drinking waters-specifications; ISIRI Number 6694, 1st Revision. Available at: www.isiri.org.
18. Institute of standards and industrial Research of Iran, 2001. Detection and enumeration of coliform Organisms in Water by Multiple tube Method; ISIRI Number 3759, 1st Edition. Available at: www.isiri.org.
19. Institute of Standards and Industrial Research of Iran, 2004. Natural mineral water-Specifications; ISIRI Number 2441, 1st Revision. Available at: www.isiri.org.
20. Miranzadeh, M.B., M. Heidari, A.R. Mesdaghinia and M. Younesian, 2011. Survey of microbial quality of drinking water in rural areas of Kashan Iran in second half of 2008. Pakistan J. Biol. Sci., 14(1): 59-63.
21. Eva, P., 2000. Survey of bottled water available in Manitaba, Canada; environmental health perspective, 108(9): 6-863.
22. Baba, A., F.S. Erees, U. Hicsonmez and S. Cam, 2007. An assessement of the quality of various bottled mineral water market in turkey. Environ Monit. Assess., (2008) 139: 277- 285.
23. Franco, R.M.B. and Cantusio Neto, 2002. Occurrence of Cryptosporidial Oocysts and Giardia Cysts in Bottled Mineral Water Commercialized in the City of Campinas. Oswaldo Cyuz., 97: 205-207.
24. Zandevakili, F., 2005. Evaluating Microbial and Physicochemical Quality of Mineral and Packaged Water in Iran; 8 th National Congress on Environmental Health, Tehran-Iran.

25. Yari, A.R., 2007. Evaluating Physical, Chemical and Microbial Quality of Packaged Water in Qom City at 2006; 10 th National Congress on Environmental Health, Hamadan.
26. Oyedeji, P.O. Olutiola and M.A. Moninuola, 2010. Microbial quality of packaged drinking water brands marketed in lbadan metropolis and lle-lfe city in South Western Nigeria, African J. Microbiol. Res., 4(1): 96 -102.
27. Food and drug Administration, 2009. References Book for Food Manufacturers Industry; Islamic Republic of Iran, Ministry of Health and Medical Education, 3rd[ed], pp: 57-58. Available at: www.ketabemarja.com.
28. Alfrij, K.M., 1999. Comparative study of potable and mineral waters available in the state of Kuwait. Desalination, 123(1999): 253-264.
29. BaBaj, I., N.N. SHASHiKiRAN and S. REDDY, 2004. Comparative evaluation of trace elements and residual bacterial of different brands of bottled waters. Indian soc. Pedo. Prev. Dent., 22(4).
30. Zeljka, F., 2007. Determination of Arsenic and Other Trace Elements in Bottled Waters by High Resolution Inductively Coupled Plasma Mass Spectrometry; Croatica Chemica Acta, CCACAA., 80(1): 91-100.
31. Soupioni, M.J., B.D. Symeopoulos and H.V. Papaefthymio, 2006. Determination of trace elements in bottled water in Greece by instrumental and radio chemical neutron activation analysis. Journal of Radio analytical and Nuclear chemistry, 268(3): 441-444.
32. Sholyk, W., 2007. lead in Bottled water: Contamination from Glass and Comparison with pristine Groundwater. Environ. Sci. Technol., 41(10): 13-35.
33. Mahmoud, A. Saleh, 2001. Evaluation of chemical bottled drinking water from Egypt; Journal of food composition and analysis, 14: 127-152.