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Investigating the Concentration of Heavy Metals in Bottled Water and Comparing with its Standard: Case Study

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ABSTRACT

Introduction: Today, bottled waters have attracted the assurance of consumers as one of the important drinking water supply resources, such that in some regions, the use of bottled waters has replaced the drinking water distribution system. The present study was carried out with the aim of measuring and determining the heavy metals in bottled water across a number of brands produced in Iran and comparing it with the drinking water standard.

Materials and Methods: In this descriptive-cross-sectional study, two different brands of bottled water were randomly sampled from the supermarket. To measure the heavy metals of interest, the samples were concentrated and then the concentration of some heavy metals such as copper, zinc, nickel, iron, aluminum, lead, and cadmium ions were measured by atomic absorption spectrophotometer. The mean concentration of ions was calculated in each brand and then compared with amount of standards.

Results: Brand No. 1, the concentration of zinc ion was larger in Brand 2 while in Brand No. 2 had larger copper, nickel, and aluminum ions. The results indicated that the concentration of the measured metal ions were below the allowable limit of drinking water standard across all of the studied samples.

Conclusion: Based on the obtained results from the investigated parameters, it can be concluded that the bottled water of both brands poses no health issue and is drinkable. Considering the changes in the concentration of ions and the increasing trend of consumption of bottled waters, their monitoring and qualitative control of pollutants are very crucial in terms of public health.

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Introduction

Water is essential for life and an important source of intake of trace elements in the human body [1]. Use of healthy and soft drinking water is one of the most important factors in water consumption, which has always been of interest to environmental health organizations [2]. Several countries rely on alternative water resources due to shortage of water resources [3]. Today, bottled waters have attracted the trust of consumers as one of the important drinking water supply resources, such that in some regions, consumption of bottled waters has replaced the drinking water distribution system [4]. A total of 75% people in the third world are deprived of facilities for accessing healthy drinking water. In many countries, bottled waters are popular thanks to their easy availability, relatively low cost, better taste, and low impurity, where there are 100 different brands of bottled waters producing and distributing in Iran, currently.

A large number of mineral compounds, especially metal ions, have a dual role in the physiology of the human body, some are essential for humans, whereas most of them are toxic at high concentrations [5, 6]. Entrance and accumulation of heavy metals in the body of creatures cause development of different chronic diseases [7, 8]. So, constant monitoring of the quality of bottled waters is important for preserving public health. The present of heavy metals in bottled water has been of interest to numerous researchers. Ghaderpouri et al (2008) worked on determining the toxic trace metals in bottled waters used in Tehran [3]. Miranzadeh et al (2010) investigated the microbial quality and concentration of heavy metals among 15 brands of bottled water produced in Iran [9]. Mahmoud et al (2008) examined the chemical, microbial and physical evaluation of commercial Bottled water in the greater Houston area of Texas [10]. Furthermore, Mahajan et al (2006) studied physiochemical analysis of the parameters of bottled drinking water. The results of these studies suggested that the values of these metals in bottled waters are below the standard and guideline values and pose no threat to consumers' health [11]. This study was performed with the aim of determining the concentration of heavy metals in bottled waters of a number of brands produced in Iran and comparing it with the drinking water standard.

Materials and Methods

This was an experimental study which performed at laboratory scale. The studied samples were prepared directly out of mineral water bottles and following concentrate the samples, the concentration of copper, zinc, nickel, iron, aluminum, lead, and cadmium ions were measured by an atomic absorption spectrometer (Spectra AA. 20 Plus, Australia by Varian) in standard mode.

For this purpose, 5 ml of 10% nitric acid was added to the samples. They were then heated to be concentrated. Following the concentration operation, the samples were filtered for measurement. Thereafter, to measure the metals in the samples, standard solutions of each sample were prepared out of pure nitrate salts, and then atomic absorption spectrometer was standardized by freshly prepared standard solutions. Finally, the concentration of the metal of interest across the samples was measured separately by the AAS.

Ethical issues

This article was approved by the Ethical Committee (ethical code: IR.SSU.SPH.REC.1394.10) of the Faculty of Health of Shahid Sadoughi University of Medical Sciences and Health Services.

Results

In this research, the concentration of 7 ions of copper, zinc, nickel, iron, aluminum, lead, and cadmium were measured in bottled drinking water. Note that these parameters were measured in 3 samples of each type of bottled water and the obtained data were saved in Excel software. The mean values and allowable of limit of drinking water are presented in the Table 1.

Table 1: The mean concentration and allowable limit

Ion	Brand 1 Mean*	Brand 2 Mean*	Allowable limit*
Cu	0.0345	0.0354	1.3
Zn	0.0321	0.0190	1.5
Ni	0.0013	0.0041	0.02
Fe	0.0050	0.0045	0.3
Al	0.0126	0.0153	2
Pb	0.0032	0.0031	0.005
Cd	< 0.0002	< 0.0002	0.003

*All unit of concentration is mg/l

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Also, for the comparison of elements in bottled waters in the two examined brands, the results of each individual element are shown in Figures 1 to 6. The obtained results for copper ions in 2 brands sample and allowable level are shown in Figure 1. The concentration of copper in brand 1 was higher than brand 2.

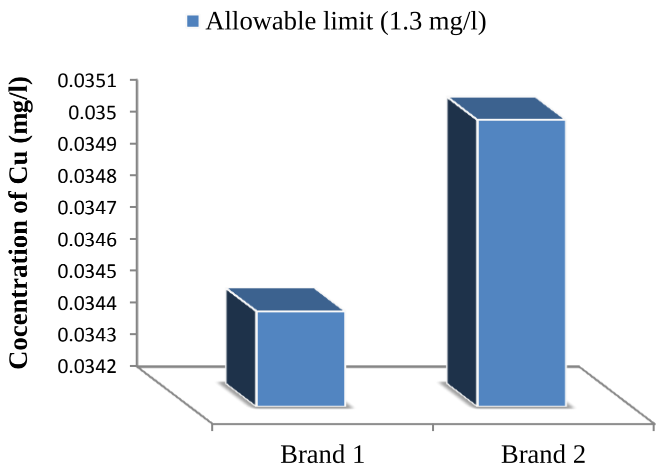

Figure 1: The mean concentration of copper in the bottled water samples with its allowable limit

The comparison and obtaining results of the zinc concentration in the two examined brands with an allowable limit of zinc in drinking water are presented in Figure 2. The concentration of zinc in brand 1 was higher than brand 2.

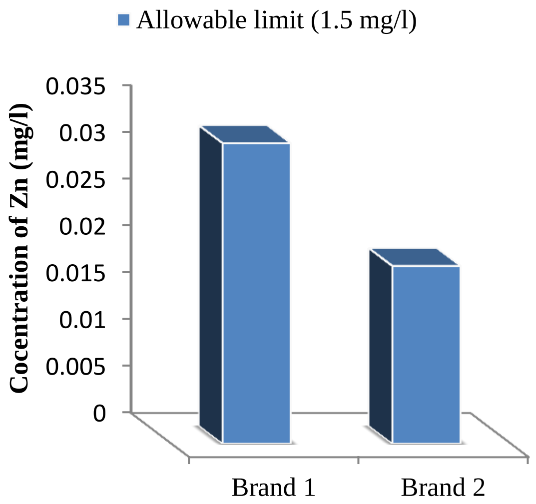

Figure 2: The mean concentration of zinc in the bottled water samples with its allowable limit

The comparison of the nickel concentration in the two examined brands is presented in Figure 3.

Figure 3 indicates that the mean nickel concentration in brand 1 was 0.0013 mg/l, and in brand No. 2 was 0.0041 mg/l, and brand 1 was slightly less than brand 2.

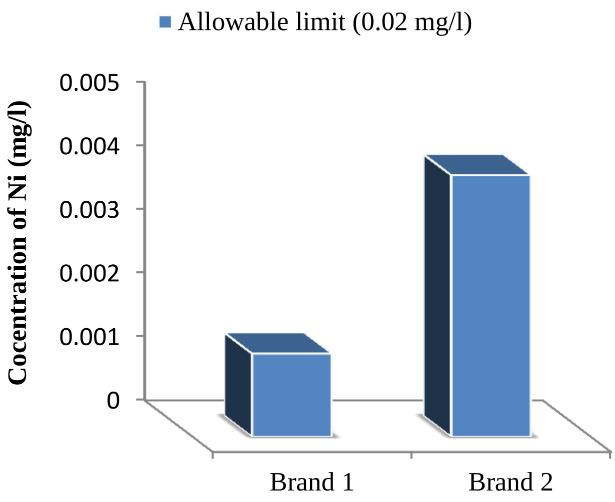

Figure 3: The mean concentration of nickel in the bottled water samples with its allowable limit

Figure 4 shows that the mean iron concentration in the two examined brands. According to Figure 4 the iron concentration in brand 1 was 0.0050 mg/l, and in brand No. 2 was 0.0045 mg/l, and brand 2 was slightly less than brand 1.

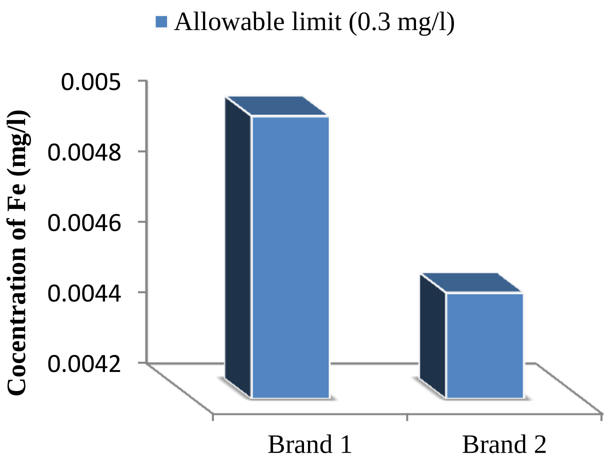

Figure 4: The mean concentration of iron in the bottled water samples with its allowable limit

The comparison of the aluminium concentration in the two examined brands is presented in Figure 5. This result indicates that the mean aluminium concentration in brand 1 was 0.0126 mg/l, and in brand No. 2 was 0.0153 mg/l, and brand 1 was slightly less than brand 2.

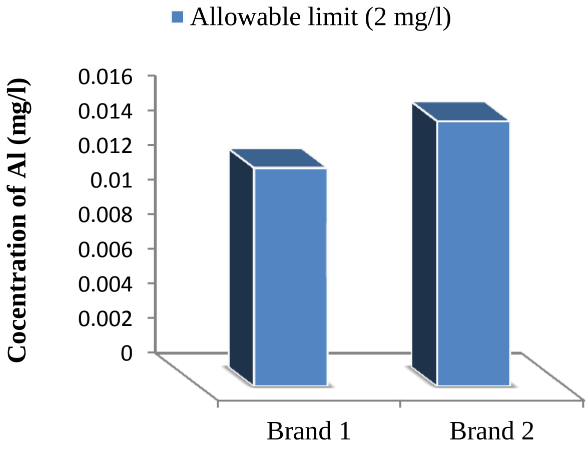

Figure 5: The mean concentration of aluminium in the bottled water samples with its allowable limit

Figure 6 shows that the comparison and average lead concentration of Lead in the two examined brands. According to Figure 6 the lead concentration in brand 1 was 0.0032 mg/l, and in brand No. 2 was 0.0031 mg/l. The lead concentration in 2 brands were observed same amount.

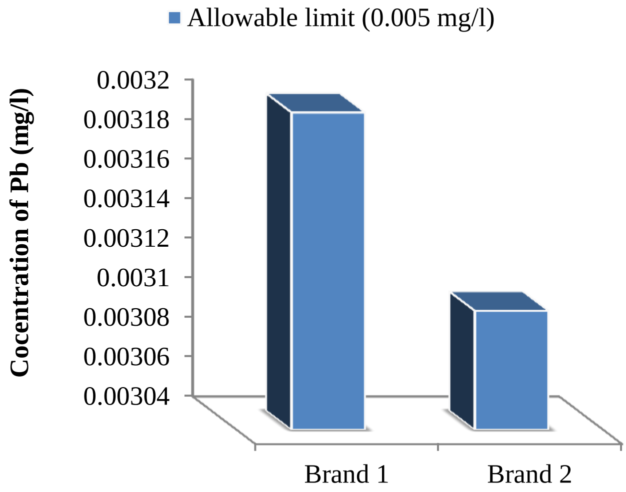

Figure 6: The mean concentration of lead in the bottled water samples with its allowable limit

The cadmium concentration in both brands was in little amounts, which could not be detected in any of the samples. The allowable limit for cadmium was 0.003 mg/l. According to Table1, the results indicated that all samples were in the bellow of the allowable limit.

Discussion

All metals are water soluble to some extent, which depends on their solubility. Iron and copper ions have a greater solubility, while lead and cadmium ions have a lower solubility compared to the other studied ions. Nevertheless, even low levels of lead and nickel can threaten human life [12]. Metals can enter the human body through various manners such as drinking water, air, and food. As metals have a greater mobility toward water and water is able to dissolve most compounds, it could be the main sources of the metal entrance to the body. Heavy metals can accumulate in the body and in such cases, the low concentration of these metals in different sources becomes important to health effect [13]. Since the polymeric containers are utilized for storing bottled water, it is probable that there will be leakage of ions used during polymerization. Though, trace amount of heavy metals has been found in the bottled water samples, their concentrations were below the limit of national and international guidelines and standards.

Across the bottled water samples, the mean concentration of copper in sample 2 was 0.0354 mg/l, which was a little higher than the concentration of copper in brand 1 (0.0345 mg/l), which had no significant difference, but its concentration was lower than the allowable limit for drinking water (10 mg/l) [14]. The reason for the higher copper concentration in this water sample can be due to the different water preparation sources or possible leakage of their containers in case of long-term storage. According to the study by Magda [15], there is a possibility that the concentration of copper increases due to leakage of the water storing bottles. The concentration of copper in the studied samples in this research (2015) was higher than in other countries, but does not pose any threat to the human health. The results obtained from copper ion values in this study were in accordance with the research by Miranzadeh et al (2010) [9], in which the concentration of heavy metals across all studied samples was in congruence with Iranian National standard and the standard set by WHO and EPA.

The nickel concentration in brand No. 2 (0.0041 mg/l) was more than brand 1 (0.0013 mg/l). Across the studied samples, the mean concentration of nickel had a significant difference across brands 1 and 2. This different concentration can be attributed to different bottled water preparation sources. However, the concentration of nickel in them is below the allowable limit for drinking water (20 mg/l) [14]. The concentration of nickel in the bottled water samples in this study was lower than that in Western Azarbaijan by Forouzan et al (2007) [16]. Furthermore, the obtained values in this study were greater than those reported by Ikem et al [17], where nickel metal was not measurable in any of the samples. This concentration across the distributed samples was lower than the values of WHO and EPA guidelines.

Across the studied bottled water samples, the mean concentration of lead in brand No. 1 was significantly different from that of another brand. This different concentration can be attributed to the different bottled water source or leakage of their containers. According to Mahajan et al [11], the concentration of lead from the bottled water containers can increase into the water contained in it with prolongation of storage time. The concentration of lead across the experimented water samples was lower than the values reported by Ikem et al, [17] also it was lower than the drinking water standard (5 mg/l) as well as WHO and EPA guidelines [2, 14]. Dos anto studied brands of domestic and imported bottled water from the markets of Curitiba-PR-Brazil, and reported the mean concentration of lead as 5 mg/l, which is greater than the lead concentration across the consumed samples in Tehran [18].

Comparison of the values of the concentration of analyzing metals indicates that the concentration of iron, copper, and lead in Brand No. 1 was maximumed, while their values were minimumed in Brand No. 2, and as mentioned earlier, it can be attributed to different reasons. Based on the comparison of the concentration of measured metals, it can be concluded that across the studied bottled water samples, the highest concentration across the measured metals was related to iron (5.51 mg/l), which is below the standards.

In terms of health, this point should be noted that metals can accumulate in human body tissues and as these ions are highly toxic, they can bring public health concerns. This study was conducted cross-sectionally and the values of the metal ions could change in samples that may be produced and may enter the market. Therefore, it is essential that these heavy metals in bottled waters are continuously monitored and controlled of pollutant, so that there would no longer be concerns on the part of consumers.

Conclusion

Based on the results of this study, the concentration of heavy metals in the studied bottled waters was lower than the allowable limit.

Thus, the these bottled waters pose no health risk to consumers in terms of these metals. Though toxic metals, even in trace quantities, can be a source of concern as an important health risk, including damage to the nervous system, kidneys and infants due to toxicity. Considering the increasing trend of consumption of bottled waters, their qualitative monitoring and controlling are very crucial in terms of public health.

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Conflict of interests

No conflict of interest has been stated by the authors

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