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Potential Health Risks of Heavy Metal Contents in Bottled Water from Local Iraqi Market

Hassan M. Salieh AL Fayadh[1*], Mazin M. Ibrahim Al-Zubaidi[2], Moath A. Najem[3]

[1]College of Education - Shaqlawa, Salahaddin University - Erbil, Iraq
Email: hassan.salieh@su.edu.krd
[2]College of Agriculture and forestry, University of mosul, Iraq
[3]College of Agriculture and forestry, University of mosul, Iraq

***Correspondence author:** Hassan M. Salieh AL Fayadh (hassan.salieh@su.edu.krd)

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Abstract

The aim of this study is to evaluate the heavy metal (Pb, Zn, Fe,Co,Mn,Cd,Cr) content and potential health risks of some bottled water brands in the local Iraqi market in comparison with Iraqi and international standards. The results showed that the pH and TDS levels were 7.09–8.25 and 39.1–294.99 ppm, respectively. All samples were identical to the specifications, except for lead and chromium. The concentration of lead was 0.01, 0.015, 0.013, and 0.01 ppm in the samples 1, 3, 4, and 8, respectively, while the concentration of chromium (0.108 ppm) was in the imported sample 11, which did not conform to the Iraqi specifications, WHO, and IBWA. The values of CDIPb oral and HQPb were somewhat high in sample 1, especially for the infant group, as they were 0.00712 and 0.50881, respectively. The values of HQCr were greater than 1 for most age groups in sample 11, as they ranged between 0.89479 and 2.374447. It was more dangerous in the infant and 6–11 age groups, as well as in sample 4. It was more than the permissible limit. Increasing the value of heavy elements is dangerous to consumer health. Therefore, water bottling companies are advised to conduct tests, monitor heavy elements, and treat them by physical or chemical methods, including the use of carbon filters.

Keywords

Bottled water, Heavy Metal, Chronic Daily Intake, Hazard Quotient

Drinking water is defined as any liquid that does not hurt people or is not significantly contaminated. An origin for halves No living thing can exist without water; hence, it is a crucial and required component of all industries and processes. It is required for all bodily interactions in neighbourhoods (Abbas, 2018). One of the basic human necessities that cannot be neglected is access to water. It must adhere to certain physical, chemical, and biological requirements, and it is a widely recognized human rights (WHO, 2022). Bottled water is one of the most common food and beverage industries. Due to consumer demand and water pollution brought on by chlorination issues, drinking water consumption is rising steadily. Water pollution generally poses a serious threat to ecosystem stability, and all factors that alter the properties or character of water can contribute to it, the bottled water industry has expanded greatly in the last ten years, the Iraqi consumer has become dependent mainly on water bottled in plastic bottles of different sizes, some of which are used once and others are used repeatedly (Alobaidy & Almahdawi, 2016).As the percentage of bottled water factories in Iraq reached 54.5% Out of all the various food industry factories in the country, the number of licensed industrial projects that produce bottled water in Baghdad reached 15 factories, compared to 234 unlicensed factories distributed among the different governorates (Razuki & Al-Rawi, 2010). People's needs for drinking water vary depending on the environment, their level of activity, their customs, and their traditions, but for the majority of consumers, they are estimated to be around two litters per day for a 70 kg person and one litter per day for a 10 kg child (Ahmed, 2021). Concerns concerning the quality of bottled water sold around the world have been expressed. Research has indicated that certain components in bottled water may have values that are higher than those for other brands' determinants (Karamanis, et al, 2007). Higher daily intake of heavy elements, especially metal ions, play a dual role in human physiology; while some are significant for humans, most of them are poisonous at high concentrations (Duffus, 2002; Karvelas & Katsoyiannis, 2003). There is no doubt that the quality and safety of water play a significant and direct role in the health of the consumer, as numerous studies have highlighted the harm caused by water containing heavy metals. Figure 1 shows how groundwater and drinking water systems around the world are contaminated by sources of heavy metals that are either natural or man-made, which have varying risks of causing mutations, embryotoxicity, their impact on the nervous system, which slows growth rates, and other disorders (Salman, 2015). Therefore, this study aims to evaluate the content of heavy metals and the potential health risks of some bottled water brands in the local Iraqi market in comparison with Iraqi and international standards.(Fernandez-Luqueno et al., 2013)

Materıals and Methods

Samples

The collecting of samples

84 samples total,12 brands, 7 samples from each brand were collected randomly from different Iraqi markets, samples were taken to the lab and kept in the refrigerator at 4°c. The information of bottled water is showed in Table (1), (according to the bottled water label). samples were put in 250 ml beaker for testing pH, Total Dissolved Solid (TDS) by using pH meter, TDS- meter respectively according to (Clesceri, 1998).

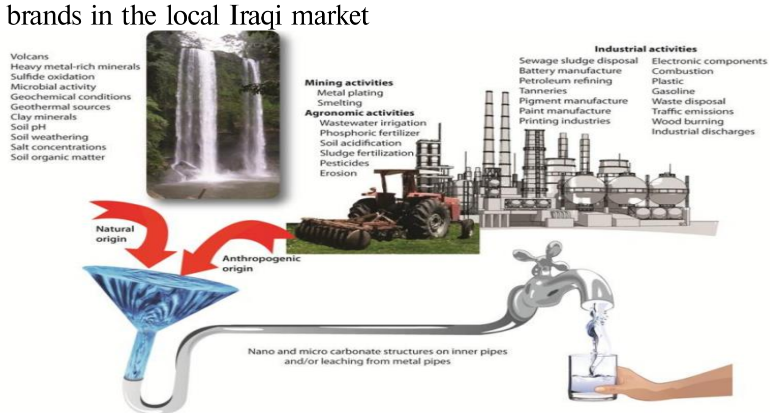

Figure 1. shows the many groundwater and drinking water systems around the world that are contaminated by natural or man-made heavy metal sources.

Table 1. Bottled water Information

Producing country	Bottle size (L)	Container	Water source	Sterilization type	Sample ID	Sample Type
Iraq	0.5	Plastic	MW	O	1	Local
Iraq	0.5	Plastic	MW	---	2	
Iraq	0.5	Plastic	SW	O	3	
Iraq	0.5	Plastic	SW	O	4	
Iraq	0.33	Plastic	---	O,UV	5	
Iraq	0.5	Plastic	---	---	6	
Iraq	0.5	Plastic	---	O,UV	7	
Iraq	0.5	Plastic	TR	O	8	
Iraq	---	---	TR	Cl	9	
Italy	0.5	Plastic	MW	---	10	Imported
Uk	0.5	Plastic	SW	---	11	
Turkey	0.33	Plastic	MW	---	12	

MW= Mineral water, SW= Spring water, TR= Tigris river , O= Ozone, UV= Ultraviolet, Cl= Chlorine.

Analysis of heavy metals

Atomic Absorption spectrophotometer was used to measure the concentrations of heavy metals (Lead (Pb), Zinc (Zn), Iron (Fe), Cobalt (Co), Manganese (Mn), Cadmium (Cd), and Chromium (Cr) in bottles water, the instrument was connected to WinLab32 software system, . Describing the Health Concerns of lead (Pb) and chromium (Cr) according to (Smith, 1995). The following formulae are used to compute the hazard quotient (HQ) and the mean daily intake (CDI) absorbed from drinking water (Al-Bhar & Al-Saffawi, 2021):

CDI oral (mg/kg. day) = (Cw ЧIR ЧEF ЧED)/ (BW ЧAT)

HQ oral = (CDI oral)/(RFD oral)

CDI: Chronic Daily Intake (mg/kg. day). HQ: Hazard Quotient , Cw: the measured lead (Pb) and Chromium (Cr) concentration for water samples. IR: The daily rate of drinking water (liters. day 1). EF: Frequency of exposure by age (day. year). ED: Duration of exposure to lead (Pb) and Chromium (Cr) (years). Bw: body weight of cohorts (kg.). AT: average time (day). RfD: Reference Dose 0.0014, 0.003 mg/Kg/Day for Pb, Cr respectively.

Results and Discussion

Twelve brands from the local Iraqi market were studied, all of which did not conform to the standard specifications that were mentioned on the label indicating the pH value and TDS value, It was free from valuable heavy metal content such as (Pb, Zn, Fe, Co, Mn, Cd ,Cr).

All values of pH and TDS that ranged between (7.09-8.25) and (39.1-294.59) ppm respectively shown in Table (2) and Figures (2,3) were in conformity with the Iraqi and international standard specifications.

The results of the current study mentioned in Table (2) and Figures (4) showed that the average of all the variables that were examined are within the Iraqi and international standards (WHO, IBWA), except for the Pb content, which was slightly more than the upper limit of Iraqi standards and the World Health Organization, and did not comply with IBWA specifications in samples IDs (1,3,4,8), It is identical to what was found (Abbas, 2018; Al-Hiyaly, Al Obaidy, & Majeed, 2014).

The content of the element Cr shown in the Table (2) and Figure (5) was not in conformity with the Iraqi and international specifications (WHO,IBWA) in the imported samples, the highest value in the sample ID 11, It is identical to what was found (ONAWUMI O., 2021)

Table (2) Heavy metals content of bottled water in the Iraqi market

ppm							
Cr	Cd	Mn	Co	Fe	Zn	Pb	Elements Samples IDs
0.041	Nil	Nil	0.0007	1.88E-5	0.008	0.01	1
0.031	Nil	Nil	0.0001	3.15E-5	0.010	0.005	2
0.032	Nil	Nil	0.0007	1E-5	0.009	0.01	3
0.048	Nil	Nil	0.0006	9.31E-6	0.011	0.01	4
0.039	Nil	Nil	0.0073	Nil	0.010	Nil	5
0.028	Nil	Nil	0.0058	1.28E-5	0.010	Nil	6
0.040	Nil	Nil	0.0042	2.93E-5	0.007	0.002	7
0.034	Nil	Nil	0.0031	3.36E-5	0.006	0.01	8
0.033	Nil	Nil	0.0027	3.01E-5	0.006	0.009	9
0.041	Nil	Nil	0.0020	2.42E-5	0.004	0.008	10
0.100	Nil	Nil	0.0015	1.7E-5	0.006	0.008	11
0.0470	Nil	Nil	0.0006	1.92E-5	0.009	0.009	12
0.05	0.003	0.05	----	0.3	3	0.01	Iraqi standard
0.05	0.003	0.1	2	0.3	3	0.01	WHO*
0.05	0.005	0.05	0	0.3	5	0.005	IBWA**

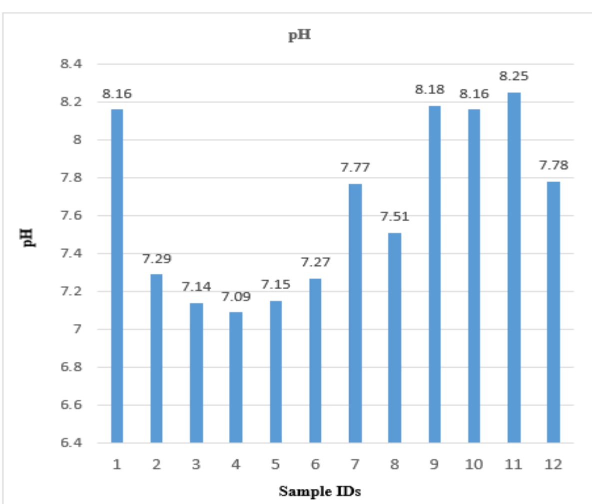

Figure 2. pH values of bottled water sample IDs in the Iraqi markets

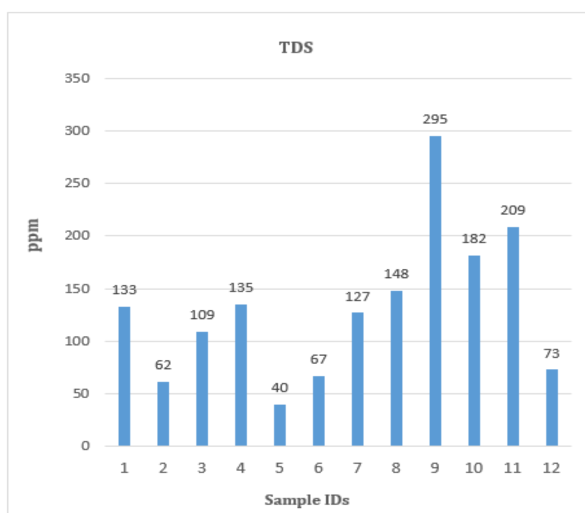

Figure 3. TDS values of bottled water sample IDs in the Iraqi markets

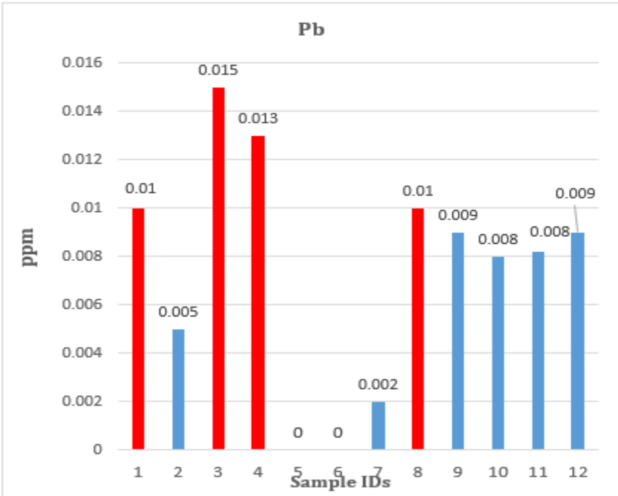

Figure 4. Lead concentration of bottled water sample IDs in Iraqi markets

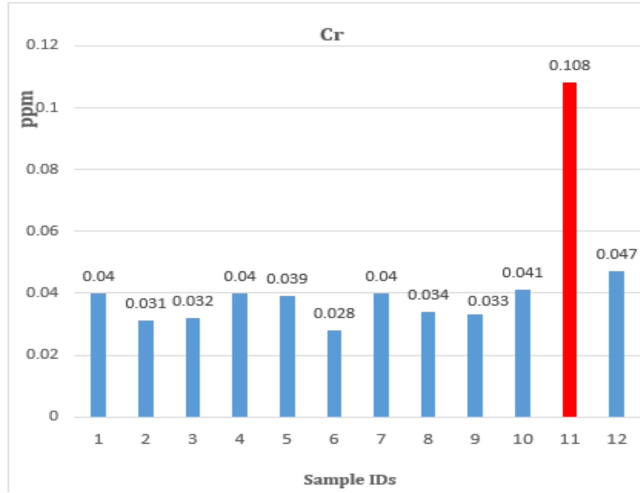

Figure 5. Chromium concentration of bottled water sample IDs in Iraqi markets

Table 3. CDIoral and HQPb results (for different cohorts) for bottled water from Iraqi markets

Sample IDS	Cohorts	Infants	6 to11	11to16	16to18	18to21	21 to Old	
							males	Females
1	CDI	0.000712	0.000450	0.000328	0.000268	0.000345	0.000386	0.000332
	HQ	0.50881	0.321794	0.234578	0.191740	0.246523	0.275364	0.237493
2	CDI	0.000356	0.000225	0.000164	0.000134	0.000172	0.000193	0.000166
	HQ	0.254405	0.160897	0.117289	0.095870	0.123261	0.137682	0.118746
3	CDI	0.001068	0.000675	0.000492	0.000402	0.000517	0.000578	0.000499
	HQ	0.0014	0.482691	0.351867	0.287611	0.369785	0.413046	0.356239
4	CDI	0.000926	0.000585	0.000426	0.000348	0.000448	0.000501	0.000432
	HQ	0.0014	0.418332	0.304952	0.249262	0.320480	0.357974	0.308741
5	CDI	0	0	0	0	0	0	0
	HQ	0	0	0	0	0	0	0
6	CDI	0	0	0	0	0	0	0
	HQ	0	0	0	0	0	0	0
7	CDI	0.000142	9.01E-05	0.000065	5.36E-05	6.90E-05	0.000501	0.000432
	HQ	0.101762	0.064358	0.046915	0.0383481	0.369785	0.357974	0.308741
8	CDI	0.000712	0.000450	0.000328	0.000268	0.000345	0.000347	0.000332
	HQ	0.50881	0.321794	0.234578	0.191740	0.246523	0.247828	0.237493
9	CDI	0.000641	0.000405	0.000295	0.000241	0.000310	0.000347	0.000299
	HQ	0.457929	0.289614	0.211120	0.172566	0.221871	0.247828	0.213744
10	CDI	0.000569	0.000360	0.000262	0.000214	0.000276	0.000308	0.000266
	HQ	0.40704	0.257435	0.187662	0.153392	0.197218	0.220291	0.189994
11	CDI	0.000584	0.000369	0.000269	0.000220	0.000283	0.000316	0.000273
	HQ	0.417224	0.263871	0.192354	0.157227	0.202149	0.225799	0.194744
12	CDI	0.000641	0.000405	0.000295	0.0002415	0.000310	0.000347	0.000299
	HQ	0.457929	0.289614	0.211120	0.172566	0.221871	0.247828	0.213744

Smith,(1995) explained if the HQ value is less than one, this indicates that the drinking water is safe and has no harmful health risks to consumers, but if the value is greater than 1, there may be potential health effects due to the consumption of water contaminated with Pb, Cr. Fortunately, the results of the lead hazard quotient HQ_{Pb} values did not exceed the dangerous limits (greater than 1.0) for all age groups studied, as the HQ values for the infant group fluctuated between (0.0 to 0.50881), it relative increase is due to a higher infant lead CDI that oscillates between (0. - 0.000712334) . As for the age group (21 to Old), HQPb values for males were relatively more than woman's, which fluctuated between (0.0 to 0.275364), while for the rest of the age groups it ranged between (0.0 to 0.246523571) as shown in Table (3). It was also noted from the table that HQ values decrease proportionally with increasing age, that the decrease in lead risk quotient HQ_{Pb} values for all age groups was mainly due to the decrease in the concentration of Pb ions in bottled water, which led to a decrease in CDI values, so it ranged for both infants, 21 to old group and the rest of the age groups between (0.0 to 0.0007123), (0. to 0.000386) and (0.to 0.000675768) consecutively. It is inconsistent with what he found (Alam, 2021; Maxwell et al., 2018).

Table 4. CDIoral and HQCr results (for different cohorts) for bottled water from Iraqi markets

Sample IDS	Cohorts	Infants	6 to11	11to16	16to18	18to21	21 to Old	
							males	Females
1	CDI	0.002921	0.001847	0.001346	0.001101	0.001415	0.001581	0.001363
	HQ	0.973523	0.6157	0.448827	0.366864	0.471682	0.526864	0.454403
2	CDI	0.002208	0.001397	0.001018	0.000832	0.00107	0.001195	0.001031
	HQ	0.736078	0.465529	0.339357	0.277385	0.356637	0.39836	0.343573
3	CDI	0.002279	0.001442	0.001051	0.000859	0.001104	0.001234	0.001064
	HQ	0.759823	0.480546	0.350304	0.286333	0.368142	0.411211	0.354656
4	CDI	0.003419	0.002162	0.001576	0.001288	0.001657	0.00185	0.001596
	HQ	1.139734	0.720819	0.525456	0.429499	0.552213	0.616816	0.531984
5	CDI	0.002778	0.001757	0.001281	0.001047	0.001346	0.001503	0.001297
	HQ	0.926034	0.585666	0.426933	0.348968	0.448673	0.501163	0.432237
6	CDI	0.001995	0.001261	0.00092	0.000752	0.000966	0.001079	0.000931
	HQ	0.664845	0.420478	0.306516	0.250541	0.322124	0.359809	0.310324
7	CDI	0.002849	0.001802	0.001314	0.001074	0.001381	0.001542	0.00133
	HQ	0.949779	0.600683	0.43788	0.357916	0.460177	0.514013	0.44332
8	CDI	0.002422	0.001532	0.001117	0.000913	0.001173	0.001311	0.00113
	HQ	0.807312	0.51058	0.372198	0.304229	0.391151	0.436911	0.376822
9	CDI	0.002351	0.001487	0.001084	0.000886	0.001139	0.001272	0.001097
	HQ	0.783567	0.495563	0.361251	0.295281	0.379646	0.424061	0.365739
10	CDI	0.002921	0.001847	0.001346	0.001101	0.001415	0.001581	0.001363
	HQ	0.973523	0.6157	0.448827	0.366864	0.471682	0.526864	0.454403
11	CDI	0.007123	0.004505	0.003284	0.002684	0.003451	0.003855	0.003325
	HQ	2.374447	1.501707	1.0947	0.89479	1.150443	1.285033	1.1083
12	CDI	0.003348	0.002117	0.001544	0.001262	0.001622	0.001812	0.001563
	HQ	1.11599	0.705802	0.514509	0.420551	0.540708	0.603966	0.520901

The results of Table 4 indicate that the chromium element hazard quotient HQ_{Cr} values exceed the dangerous limits (greater than 1.0) for most age groups studied, as the HQ values for the infant group fluctuated between 0.664845 and 2.37447. The highest HQ_{Cr} value was in the imported sample ID 11; it is the same in most age groups. Also, in the samples ID 4, 12, and HQ, there were more than 1 in the infant group, indicating that the increase is due to a higher infant CDI_{Cr} that oscillates between 0.001995 and 0.007123. Male HQ values were slightly higher than females, ranging between 0.359809 and 1.285033, while the rest of the age groups ranged between 0.420478 and 1.150443. It is inconsistent with what he found (Alam, 2021; Maxwell et al., 2018).

Conclusion

We conclude that all samples were less than the permissible limit recommended by the Iraqi specifications, WHO and IBWA, except for lead and chromium in some local and imported samples that had more than 1 HQ consequently, drinking water that contains high levels of heavy metals, including lead and chromium, causes health risks, especially for young children. Therefore, we recommend water-bottling companies to monitor and conduct periodic checks for heavy elements and mention them on the label of the can. Bottled water is subjected to chemical or physical treatment to reduce water contamination in heavy elements.

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