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Risk of heavy metal contamination in bottled drinking water in Iraq

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ABSTRACT

Goal No.6 (SDG's) are dedicated to ensuring the availability and access to clean drinking water around world. Bottled drinking water (BDW) become the safest choice for many people in Iraq due to the lack of credible tap water sources. To assess the validity of BDW sold in Iraq-Baghdad 40 samples were examined for the presence of toxic heavy metals (Cr, Cd, Ni, Mn and Fe) using Atomic Absorption Spectrometry. Then we checked if the concentration safe according to Iraqi and WHO standard. The result revealed that concentrations of Cr, Ni and Pb up over the permissible levels, while Cd and Mn were not detected any more. The presence of Cr, Ni and Pb in BDW have many health risk especially for children. Thus our study suggested activating the periodic examination on the bottled drinking water by the competent authorities and environmental humanitarian organizations.

Key words: Bottled drinking water, Heavy metal, Risk assessment, Iraq.
Article type: Report.

INTRODUCTION

While considerable progress has been made in increasing order in access of people to clean drinking water and sanitation. The united nation reports mention that 1 in 3 people around the world do not have access to safe drinking water. Sustainable Development Goals (SDGs) in goal No. 6 are dedicated to ensuring the availability and access to clean drinking water (United Nation 2022). However, by lifestyle changes and human population size increase, the demand for water "for different uses" has been increased dramatically. As a result, water quality has become of special concern (Pereda 2016). This importance has stimulated many international authorities to develop international standards for water quality. The WHO (World Health Organization) Guidelines for the Quality of the Drinking Water (WHO 2017) provided the standard framework that boosts national standards in different countries and covers a far wider range of water quality parameterization. Recently the drinking water quality considered as one of the most critical concern around world, i.e., in Swedish market (Rosborg *et al.* 2005); Italy (Cicchella *et al.* 2010); Iran (Miranzadeh *et al.* 2011); Egypt and Saudi Arabia (Abdelaal *et al.* 2015); also in Iraq (AL Dulaimi & Younes 2017; Talib Jawad *et al.* 2022; Al-Taee *et al.* 2024). Tigris River is the main water supply for Baghdad City for drinking water. Its quality was acceptable and tend to be slightly polluted due to anthropogenic activity (Al Sudani 2021). Water treatment plants for housing uses, pumping stations and water supplying networks suffered from lack of maintenance "due to wars" resulting breakdown (Stars Orbit Consultants and Management Development 2010). A customer satisfaction survey was conducted by the Directorate of Water in Baghdad municipalities showed that customers avoid drinking tap water, fearing that it is contaminated. The uncertainty of tap water quality in Iraq "after war" has caused an increase in the number of local bottled drinking water factory around Baghdad (Abbas *et al.* 2016). The current study aimed to assess the risk of presence of heavy metal in bottled drinking water in order to come up with some recommendation useful for society.

MATERIALS AND METHODS

Sample collection

Bottled drinking water samples were collected randomly from different market in Baghdad City (33°14'-33°25' N, 44°31'-44°17' E). Some samples were chosen deliberately, since they were special for child. So the risk may be greater than other type for mature persons. The brand of bottled drinking water used in our study was hidden to avoid commercial marketing.

Heavy metal determinations

The bottled drinking water samples sent to Environmental Research Centre Laboratory, University of Technology, Baghdad. The presences of heavy metal determinations were done by Atomic Absorption Spectrometry (AAS 6300, Shimadzu, Japan). The Bottled drinking water samples were treated according to the method APHA, 2005 (APHA 2005).

Statistical analysis

Analysis results data of water samples were subjected to statistical analysis methods such as mean, standard division (SD) and variance to increase the reliability of our findings. All this mathematically processes were done online by help of https://www.calculator.net/.

RESULTS AND DISCUSSION

One of the most important questions that arise when conducting any environmental investigation is the extent of the hazard or impact of these pollutants whom we are investigating. Exposure to heavy metal for long times leading to many health problems can be detected in various organs, physiological disorders and carcinogenic diseases in human bodies (Morris *et al.* 1992; Yang *et al.* 1998). Such pollutants may accumulate in different organs, leading to abortions and teratogenic effects (NRDC 1999).

Table 1. The heavy metals concentrations (mg L^{-1}) in the bottled drinking water samples.

Code	Use for	Cr	Cd	Ni	Mn	Pb
1	Regular	ND	ND	0.5510	ND	0.5268
2	Regular	ND	ND	0.9235	ND	0.9721
3	Children	0.1320	ND	ND	ND	1.9950
4	Children	0.0340	ND	ND	ND	2.0061
5	Children	0.0900	ND	ND	ND	0.1016
6	Children	0.0343	ND	ND	ND	0.1159
7	Regular	0.0034	ND	0.0976	ND	0.1245
8	Regular	0.0065	ND	0.1358	ND	0.1878
9	Regular	0.0012	ND	0.1268	ND	0.1561
10	Regular	0.0021	ND	0.1672	ND	0.2251
11	Regular	0.0023	ND	0.1358	ND	0.1533
12	Regular	0.0023	ND	0.2098	ND	0.2165
13	Regular	0.0015	ND	0.1672	ND	0.2308
14	Regular	0.0029	ND	0.1941	ND	0.2345
15	Regular	0.0124	ND	0.7350	ND	0.4123
16	Regular	0.0245	ND	0.2929	ND	0.2345
17	Regular	0.0040	ND	0.1355	ND	0.9950
18	Regular	0.0009	ND	0.1264	ND	4.0061
19	Regular	0.0043	ND	0.1670	ND	0.1002
20	Regular	0.0134	ND	0.1351	ND	0.1105
21	Regular	0.1065	ND	0.2092	ND	0.1223
22	Regular	0.1623	ND	0.1673	ND	0.1823
23	Regular	0.1076	ND	0.1934	ND	0.1545
24	Regular	0.0278	ND	0.7340	ND	0.2229
25	Regular	0.1239	ND	0.2900	ND	0.1500

26	Regular	0.0340	ND	0.1343	ND	0.2126
27	Regular	0.0040	ND	0.1234	ND	0.2301
28	Children	0.0123	ND	0.1665	ND	0.2325
29	Children	0.1043	ND	0.1312	ND	0.5246
30	Regular	0.0234	ND	0.2000	ND	0.9234
31	Regular	0.1005	ND	0.1623	ND	0.9930
32	Regular	0.1002	ND	0.1923	ND	4.0060
33	Regular	0.0002	ND	0.5315	ND	0.1002
34	Regular	0.0013	ND	0.2900	ND	0.1234
35	Regular	0.0023	ND	0.1324	ND	0.1134
36	Regular	0.0015	ND	0.1245	ND	0.1123
37	Regular	0.0156	ND	0.1612	ND	0.1452
38	Regular	0.1024	ND	0.1324	ND	0.2123
39	Regular	0.0045	ND	0.2010	ND	0.1428
40	Regular	0.0340	ND	0.1603	ND	0.2412
41	Regular	0.0215	ND	0.1921	ND	0.2553
42	Regular	0.0043	ND	0.2330	ND	0.2156
43	Regular	0.1004	ND	0.2345	ND	0.4325
44	Regular	0.0065	ND	0.1318	ND	0.6752

The result revealed that three heavy metals were detected in the bottled drinking water (Cr, Ni and Pb); the highest concentrations were 0.1623; 0.9235 and 4.0060 mg L^{-1}, while the lowest 0.0002, 0.1264 and 0.1002 mg L^{-1} respectively (Table 1).
The detected concentrations of Cr, Ni and Pb were up over the permissible levels according to Iraqi and WHO standard. But two elements (Cd and Mn) of the tested heavy metals were ND (Table 2).

Table 2. The Mean ± SD (mg L^{-1}) of the heavy metal concentrations compared to Iraqi and WHO standards.

parameter	Mean ± SD (mg L^{-1})	Variance, s^2	Iraqi standard (mg L^{-1})*	WHO standard (mg L^{-1}) **
Chromium	0.0374 ± 0.0470	0.0022	0.05	0.05
Nickel	0.2818 ± 0.3352	0.1123	0.02	0.070
Manganese	ND	ND	0.05	0.1
Lead	0.5870 ± 1.0013	1.0026	0.05	0.010
Cadmium	ND	ND	0.01	0.003

*(21), ** (17).

Chromium level was 0.1623 mg L^{-1} over the maximum acceptable concentration (MAC) according to Iraqi and WHO standards for drinking water. Chromium occurs naturally in small amounts in rocks and soils, but more than 70% of chromium comes from anthropogenic activity such as non-ferrous base metal smelters, refineries, leather tanning industries.
The toxicity of chromium in humans varies depending on the form of the compound, its oxidation state and the route of exposure (Sattari *et al.* 2019a,b). Studies showed that there is little, however, many studies proven the toxicity of the hexavalent form, which is soluble in natural water and represent most of the chromium present in drinking water (Canadian Health Authority 2016). Lead was the highest concentrations up to five times more than allowable concentration (Fig. 1).
Lead toxicity can occur once entering the body. Normally just small amounts of lead consumed over time that accumulated and leading to health problems (Sattari *et al.* 2019 c,d; Forouhar Vajargah *et al.* 2021). The most affected group is children due to the growing period specially build up the bones where the lead deposited (World Health Organization 2011). Our study revealed the increased lead concentration over MAC according to Iraqi and WHO standards for drinking water. The high concentration of lead in bottled drinking water in Iraq also was found by (Al Hiyaly *et al.* 2013). Nickel reported as responsible for a decreased fertility in mice. Recently short-term toxicity experiment (28 days) suggested that nickel may also cause testicular degeneration in rats (EFSA Panel on Contaminants in the Food Chain (CONTAM) 2020).

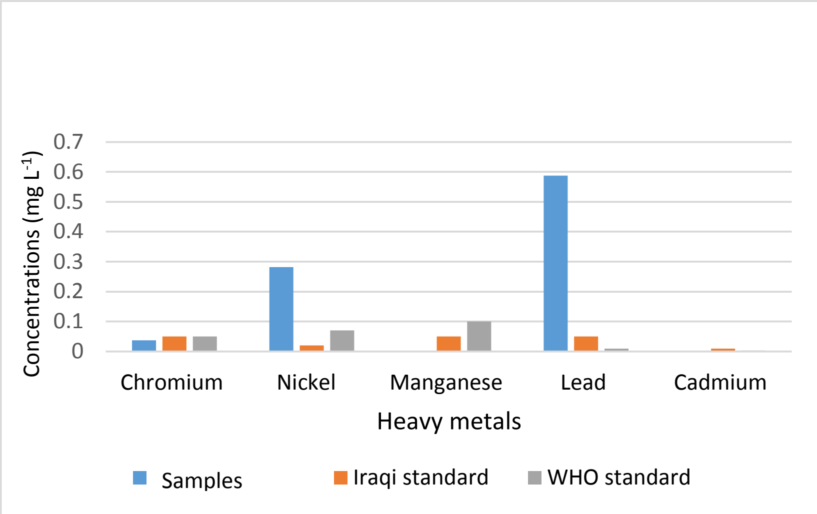

Fig. 1. The heavy metal concentrations compared to Iraqi and WHO standards.

The current study detected that nickel level in bottled drinking water tested was higher than Iraqi and WHO standards for drinking water. Nickel source in Iraqi inland water may coming from different sources. The nickel concentrations in oil range from a few to over 250 ppm. In the conversion of crude oils to transportation fuels, one of the problems will be observed (Reynolds 2001). Six of the study samples were marketing as special water for children. According to the present study findings, the chromium concentration was 0.06 mg L^{-1}, while the acceptable level according to Iraqi and WHO standards was 0.05 mg L^{-1}. In addition, lead level, as one of the most dangerous metal for human health, was 0.8 mg L^{-1}, close to twice over the acceptable level according to Iraqi and WHO standards.

CONCLUSION

1- The presence of heavy metal make the BDW not safe anymore; thus dedicated national monitoring programs may urgently needed.
2- BDW for children should have more attentions.
3- New active water purification techniques have to be adopted.
4- Health check of the children to ensure no sign of toxicity due to heavy metal presence.

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