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# Evaluation the concentration of mercury, zinc, arsenic, lead and cobalt in the Ilam city water supply network and resources

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**Abstract**

**Background:** The presence of heavy metals in water resources above threshold levels can be toxic and carcinogenic for consumers. This study determined the concentrations of heavy metals in the drinking water distribution network and resources of the city of Ilam in Iran.

**Methods:** In this cross-sectional study from 6 sources of water supply and also, different parts of the water supply system of Ilam city, samples were collected based on standard sampling methods. The samples were tested with a BRAIC atomic absorption spectrophotometer. The data was analyzed using nonparametric Mann-Whitney test.

**Results:** The concentration of zinc in all water sources of the city of Ilam was higher than WHO guidelines and Iranian standard 1053. Contamination by cobalt, arsenic and lead from Ilam dam, Pich-e Ashoori well and Haft Cheshmeh well was higher than national and international standards. The amount of cobalt and mercury at Ilam dam was significantly different from the levels at other sources ($P < 0.05$).

**Conclusion:** The use of pesticides in the agricultural sector, contamination of water by human waste and aged and worn water pipes are the likely sources of the increased concentrations of heavy metals, especially lead and arsenic. Because there is a cumulative effect from these metals, appropriate measures are necessary by the relevant agencies to address this problem.

**Keywords:** Water resources, Distribution network, Heavy metals, Ilam

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## Introduction

Population growth has increased the use of water for consumption, agriculture, industry and other uses. This not only affects the quantity of water resources, but also reduces their quality (1,2). Today, in addition to microbial contamination, chemical contamination is a major safety issue related to water.

Contamination of water resources by heavy metals is a serious environmental problem (3,4). High levels of heavy metals in the water have adverse effects on human health (5). Metals enter water resources either naturally or through contamination. Rock and soil in contact with water are the largest natural source of contamination by heavy metals (6). Major sources of industrial pollution, such as mining, and some fertilizers can lead to disposal of untreated or semi-refined wastewater containing heavy metals (7,8).

Heavy metals do not degrade; they gradually precipitate and accumulate in fatty tissues, muscles, bones and joints of creatures (9). Mercury, lead, arsenic and metals that exhibit high electronegativity, such as nickel and cobalt, have a strong affinity for amino groups and sulfhydryl groups. Enzymes are destroyed by these metals and lose power. In addition, metals enter and disrupt human metabolism (10,11).

Lead, zinc, cadmium, arsenic, cobalt and mercury are among the most dangerous poisons (12). Arsenic is not a heavy metal, but a metalloid (13). The main target of arsenic is the brain. Skin cancer can also be an effect of chronic exposure to arsenic (14). Lead can cause mental retardation, behavioral disorders, memory problems and mood changes. The most important effects of lead is impairment of the neurological development of children (15). Zinc can cause lung, prostate and kidney cancer. Cobalt can cause skin and cellular damage. Mercury can impair the senses of touch, sight and hearing (16).

Many studies have examined the role of heavy metals on human health in various aquatic environments. Babaei et al (14) in Kashmir, Ghaemi et al in Tehran (17), Mohammedan et al in Zanjan (18), Baptista et al in Brazil (19), Wang et al in China (20) and Zorer et al in Turkey (21) have all conducted such studies. The drinking water in Ilam, Iran derives from various dams and well in the region. The present study evaluated the quality of the drinking water in the distribution network resources for Ilam for the presence of heavy metals (mercury, zinc, arsenic, lead and cobalt) and compared the percentages with national standards and international guidelines.

## Materials and Methods

The present research is a cross-sectional study conducted in 2015. After competing the necessary surveys and library research and identifying the resources and water distribution networks of Ilam, the appropriate sample size was determined. To ensure coverage of Ilam for sampling, water reservoirs and the distribution networks associated with each storage tank were selected as sampling stations. A total of six water sources were determined for Ilam: Gham Gerdalan (Ilam) dam, Pich-e Ashoori well, Haft Cheshmeh well, the Ghoch Ali wells, Naghlieh well and Gol Gol spring.

Sampling was conducted monthly over the course of four months. At each sampling time, 30 samples (6 source of drinking water and 4 samples from any source distribution network) were collected. Throughout the sampling period, 120 samples were collected and sent to the laboratory. Sampling, storage and fixing of the samples was performed according to standard methods (22). The samples were transferred to the Laboratory of Pharmacology to determine the levels of mercury, zinc, arsenic, lead and cobalt. Samples were tested using an atomic absorption spectrophotometer (BRAIC; model WFX-130; China). To determine the concentration of these metals in the distribution network resources, the data was analyzed at a significance level of $P = 0.05$. Because non-normal data was used, the non-parametric Mann-Whitney test was applied in SPSS software. The results were compared with national standards (standard 1053 for Iranian water) and international standards (WHO and USEPA; Table 1).

**Table 1.** Average concentration of heavy metals, according to national and international standards

| Heavy metals | National and international standards | | |
|---|---|---|---|
| | WHO | EPA | Standard 1053 of Iran |
| Lead (mg/L) | 0.01 | 0.015 | 0.05 |
| Arsenic (mg/L) | 0.01 | - | 0.005 |
| Mercury (mg/L) | 0.001 | - | 0.006 |
| Zinc (mg/L) | 5 | 5 | 3 |
| Cobalt (mg/L) | - | 0.005 | 0.005 |

## Results

Table 2 lists the mean, standard deviation (SD) and minimum and maximum concentrations of mercury in drinking water sources Ilam. The results show that from the six main sources of drinking water in Ilam, only Ilam dam and Gol Gol spring show traces of mercury. No other source was found to contain mercury. The mercury concentration in the drinking water sources of Ilam was lower than the average concentration of heavy elements in accordance with national and international standards.

Table 3 shows that the concentration of zinc in all water sources in the city of Ilam was higher than national and international standards. The maximum amount of zinc recorded was 6.0440 mg/L from Naghlieh well. The minimum concentration was recorded for Gham Gerdalan dam.

The results showed that the arsenic levels in water resources of Ilam dam and Gol Gol spring were higher than the national and international standards, but all other sources recorded values below these standards. The lowest amount of arsenic was observed in Naghlieh well (0.0038 mg/L; Table 4).

Table 5 shows that the concentrations of lead at Ilam dam and Gol Gol spring were higher than the national and international standards. All other sources of drinking water for Ilam recorded concentrations below these standards. The lowest amounts of lead were observed in Haft Cheshmeh well (0.0075 mg/L) and Naghlieh well (0.0078 mg/L).

Table 6 shows the amount of cobalt in drinking water sources of Ilam. The results showed that the maximum concentration of cobalt was found in Naghlieh well (0.042 mg/L) and Ilam dam (0.014 mg/L). Cobalt concentrations

**Table 2.** Mean, SD, minimum and maximum concentrations of mercury in drinking water of Ilam

| Water resources | $Hg (mg\ L^{-1})$ | | | | |
|---|---|---|---|---|---|
| | N | Mean | SD | Minimum | Maximum |
| Gham Gerdalan dam | 20 | 0. 000605 | 0.0001938 | 0.0003 | 0.0009 |
| Pich Ashoori well | 20 | 0.000 | 0.000 | 0.000 | 0.000 |
| Haft Cheshmeh well | 20 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ghoch Ali wells | 20 | 0.000 | 0.000 | 0.000 | 0.000 |
| Naghlieh well | 20 | 0.000 | 0.000 | 0.000 | 0.000 |
| Gol Gol | 20 | 0.000215 | 0.0000233 | 0.000 | 0.0009 |

Abbreviation: SD, Standard Deviation.

**Table 3.** Mean, SD, minimum and maximum concentrations of zinc in drinking water of Ilam

| Water resources | Zn (mg/L) | | | | |
|---|---|---|---|---|---|
| | N | Mean | SD | Minimum | Maximum |
| Gham Gerdalan dam | 20 | 4.4050 | 1.02211 | 2.90 | 5.80 |
| Pich Ashoori well | 20 | 5.0950 | 0.20641 | 4.80 | 5.50 |
| Haft Cheshmeh well | 20 | 5.0755 | 0.49318 | 4.70 | 5.71 |
| Ghoch Ali wells | 20 | 4.6925 | 0.39633 | 4.00 | 5.60 |
| Naghlieh well | 20 | 6.0440 | 0.68015 | 4.50 | 5.80 |
| Gol Gol | 20 | 4.7950 | 0.62275 | 3.60 | 5.60 |

Abbreviation: SD, Standard Deviation.

**Table 4.** Mean, SD, minimum and maximum concentrations of arsenic in drinking water of Ilam

| Water resources | As (mg/L) | | | | |
|---|---|---|---|---|---|
| | N | Mean | SD | Minimum | Maximum |
| Gham Gerdalan dam | 20 | 0.05075 | 0.00715 | 0.0350 | 0.0620 |
| Pich Ashoori well | 20 | 0.0095 | 0.00153 | 0.0070 | 0.0120 |
| Haft Cheshmeh well | 20 | 0.0062 | 0.00034 | 0.0058 | 0.0070 |
| Ghoch Ali wells | 20 | 0.0051 | 0.00074 | 0.0035 | 0.0061 |
| Naghlieh well | 20 | 0.0038 | 0.00020 | 0.0300 | 0.0042 |
| Gol Gol | 20 | 0.0507 | 0.007293 | 0.0035 | 0.0360 |

Abbreviation: SD, Standard Deviation.

**Table 5.** Mean, SD, minimum and maximum concentrations of lead in drinking water of Ilam

| Water resources | Pb (mg/L) | | | | |
|---|---|---|---|---|---|
| | N | Mean | SD | Minimum | Maximum |
| Gham Gerdalan dam | 20 | 0.06770 | 0.01067 | 0.0500 | 0.0850 |
| Pich Ashoori well | 20 | 0.01688 | 0.00116 | 0.0150 | 0.0186 |
| Haft Cheshmeh well | 20 | 0.00750 | 0.00082 | 0.0060 | 0.0089 |
| Ghoch Ali wells | 20 | 0.01591 | 0.00353 | 0.0100 | 0.0220 |
| Naghlieh well | 20 | 0.00789 | 0.00091 | 0.0060 | 0.0089 |
| Gol Gol | 20 | 0.06640 | 0.01682 | 0.0450 | 0.0870 |

Abbreviation: SD, Standard Deviation.

**Table 6.** Mean, SD, minimum and maximum concentrations of cobalt in drinking water of Ilam

| Water resources | Co (mg/L) | | | | |
|---|---|---|---|---|---|
| | N | Mean | SD | Minimum | Maximum |
| Gham Gerdalan dam | 20 | 0.01412 | 0.00407 | 0.0090 | 0.0200 |
| Pich Ashoori well | 20 | 0.00890 | 0.00083 | 0.0070 | 0.0100 |
| Haft Cheshmeh well | 20 | 0.00189 | 0.00016 | 0.0013 | 0.0022 |
| Ghoch Ali wells | 20 | 0.00045 | 0.00008 | 0.0003 | 0.0006 |
| Naghlieh well | 20 | 0.04230 | 0.00435 | 0.0350 | 0.0500 |
| Gol Gol | 20 | 0.00037 | 0.00016 | 0.0001 | 0.0007 |

Abbreviation: SD, Standard Deviation.



were also recorded at the Ghoch Ali wells.

Comparison the results of heavy elements present in all water sources are shown in Table 7. The results show that there was a significant difference between the amount of mercury found at Ilam dam and other sources of drinking water ($P<0.05$). There was no significance difference ($P>0.05$) between the concentration of zinc found at Ilam dam, Ghoch Ali wells and Gol Gol spring, but compared to the other sources, there was a significant difference ($P<0.05$). The arsenic concentrations at Ilam dam and Gol Gol spring showed no significant difference, but these values were significantly different from the amount found in the other sources ($P<0.05$). There was no significant difference ($P>0.05$) between of the concentrations of lead at Ilam dam and Gol Gol spring, but these values were significantly different when compared with the other sources ($P<0.05$). The concentration of cobalt at Ilam dam was significantly different from those at the other sources ($P<0.05$).

Figure 1 shows the differences in zinc concentrations for the different sources of drinking water of Ilam. Figure 2 shows the differences in the concentrations of other heavy elements.

## Discussion

The use of heavy metals in industry has caused these metals to enter the environment in various ways. Heavy metals play essential roles in living bodies for building

**Table 7.** Comparison of heavy metal concentrations in drinking water of Ilam

| Water resources | | *P* value | | | | |
|---|---|---|---|---|---|---|
| | | Hg | Zn | As | Pb | Co |
| Gam Gerdalan dam | Pich Ashoori well | < 0.001 | 0.004 | < 0.001 | < 0.001 | < 0.001 |
| | Haft Cheshmeh well | < 0.001 | 0.005 | < 0.001 | < 0.001 | < 0.001 |
| | Ghoch Ali wells | < 0.001 | 0.626 | < 0.001 | < 0.001 | < 0.001 |
| | Naghlieh well | < 0.001 | 0.009 | < 0.001 | < 0.001 | < 0.001 |
| | Gol Gol | < 0.001 | 0.286 | 1.0 | 0.996 | < 0.001 |
| Pich Ashoori well | Haft Cheshmeh well | 1.0 | 1.0 | 0.999 | 0.007 | < 0.001 |
| | Ghoch Ali wells | 1.0 | 0.253 | 0.998 | 0.999 | < 0.001 |
| | Naghlieh well | 1.0 | 1.0 | 0.991 | 0.011 | < 0.001 |
| | Gol Gol | < 0.001 | 0.581 | < 0.001 | < 0.001 | < 0.001 |
| Haft Cheshmeh well | Ghoch Ali wells | 1.0 | 0.305 | 1.0 | 0.01 | 0.434 |
| | Naghlieh well | 1.0 | 1.0 | 1.0 | 1.0 | < 0.001 |
| | Gol Gol | < 0.001 | 0.650 | < 0.001 | < 0.001 | 0.372 |
| Ghoch Ali wells | Naghlieh well | 1.0 | 0.402 | 1.0 | 0.032 | < 0.001 |
| | Gol Gol | < 0.001 | 0.994 | < 0.001 | < 0.001 | 1.0 |
| Naghlieh well | Gol Gol | < 0.001 | 0.755 | < 0.001 | < 0.001 | < 0.001 |

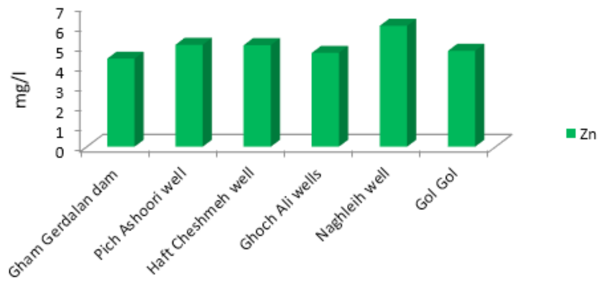


**Figure 1.** Concentrations of zinc in sources of drinking water of Ilam.

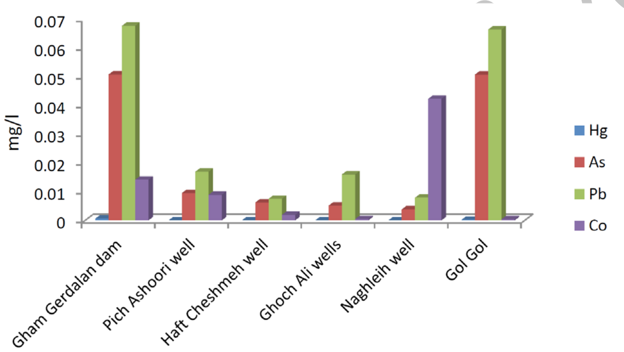


**Figure 2.** Concentrations of mercury, arsenic, lead and cobalt in sources of drinking water of Ilam.

molecules and acting as coenzymes. Some metals within a specific desirable amount are essential to life. The amount of metals in different ecosystems is influenced by different factors. They may occur through in aquatic systems as the results of natural factors, such as soil erosion and flooding, or by artificial factors, including human activity (23).

The results indicate that the contamination of Ilam dam and Gol Gol spring with arsenic, lead and cobalt is higher than at other sources. It appears that pollution by heavy metal from these two sources originated from human and animal waste, agricultural activity, feeder, cattle and poultry farms, asphalt factories, stone crushers, greenhouse complexes and landfill in the area through which the river basin flows into Ilam dam and Gol Gol spring. Pollution of the drinking water with mercury was lower than the national and international standards. The maximum concentration of zinc pollution was recorded at Naghlieh well (6.044 mg/L).

Orhan Gendoz et al evaluated arsenic levels in the Simav plain in Turkey and reported that the average concentration of arsenic was 0.099 mg/L and the maximum was 0.561 mg/L (24). Mosaferi et al studied arsenic levels in water resources in Hashtrood in Iran and found that arsenic in the drinking water of 50 villages was higher than the national standard (25). In the current study, the concentrations of arsenic in at Gam Gerdalan dam and Gol Gol spring were high and above national and international standards. At the other resources, it was lower than national international standards.

The difference in arsenic levels could be due to the use of herbicides in agricultural land in the dam basin. A survey in 2013 by Ho et al on surface and internal contamination of estuarine sediment of the Kam River in Haiphong in Vietnam with heavy metals found that the development of industrial and agricultural activity in the region had significantly increased pollution by heavy metals such as lead, zinc and arsenic (26).

Nahid et al examined heavy metals in the drinking water in different parts of the city of Tehran in Iran and concluded that the concentration of lead in some areas was higher than USEPA standards (27). Mohammedan et al examined pollution of water wells in Zanjan and showed that lead concentrations in the water resources in Zanjan were above WHO standards. In the present study, the amount of lead in the water supply at Ilam dam was 0.0679 mg/L and at Gol Gol spring was 0.0661 mg/L, which are above national and international standards.

High levels of lead can be of natural or human origin. Lead particles from gasoline combustion directly or indirectly land on the surface of the soil and plants and ultimately enter water systems. The existence of high levels of lead in the water supply at Ilam dam, Gol Gol spring and the water distribution network could have originated from the entry of lead from aging pipes and fittings used in water distribution systems themselves.

Savari et al investigated heavy metals in water resources in the city of Ahvaz in Iran and reported the amount of zinc to be 3.18 mg/L. This is inconsistent with the results of the present study which found that the concentrations of zinc in all water resources of Ilam was higher than that amount. High levels of elements like cobalt and zinc in the wells of Ilam were caused by the shallowness of the wells and the type of soil.

## Conclusion

The results show that the sources of contamination of Ilam dam and Gol Gol spring with heavy metals were higher than national standards and USEPA and WHO guidelines. Zinc concentrations in all water sources were higher than the standard level; thus, it is necessary for authorities to initiate necessary action to decrease these amounts. The high levels of lead at Ilam dam and Gol Gol spring also require measures such as use of lead-free pipes and replacement of the aging pipe network.

Because of the importance of heavy metal pollution and the increase in the population and industry, it is necessary that sources of drinking water in Ilam should be monitored continuously to assure that they adhere to lawful standards. It is recommended that all industries, manufacturing units and contaminated human and natural resources should be examined in the catchment area to determine the main causes of water contamination at each station area. Failure to monitor and control these resources will exacerbate the influence of heavy metals threatening the welfare of the urban population of Ilam. It is recommended that water from some sources that contain higher concentrations of these metals should be mixed with other water sources having lower concentrations to reduce the amount consumed and prevent the accumulation of heavy metals in the food chain and the ecosystem.

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## Ethical issues

This manuscript is the original work of the authors. It has not been published elsewhere nor is it under review in another journal. It has not been submitted for publication elsewhere.

## Competing interests

The authors declare that we have no competing interests.

## Author contribution

All authors contributed equally and participated in the collection, analysis and interpretation of the data. All authors critically reviewed, refined and approved the manuscript.

## References

1. Buragohain M, Bhuyan B, Sarma HP. Seasonal variations of lead, arsenic, cadmium and aluminium contamination of groundwater in Dhemaji district, Assam, India. Environ Monit Assess 2010; 170(1-4): 345-51. doi: 10.1007/s10661-009-1237-6.
2. Rabani M, Jafarabadi Ashtiani A, Mehrdadsharif A. The measurement of heavy metal (Ni.Pb.Hg) pollution in sediments of the Persian Gulf/operational area Assaluyeh. Journal of Environmental Science and Technology 2008; 9(3): 23-31. [In Persian].
3. Shahriari A. Determination of heavy metals (Cd, Cr, Pb, Ni) in edible tissues of Lutjans Coccineus and Tigeratooh Croaker in the Persian Gulf-2003. J Gorgan Univ Med Sci. 2005; 7(2): 65-7. [In Persian].
4. Lesmana SO, Febriana N, Soetaredjo FE, Sunarso J, Ismadji S. Studies on potential applications of biomass for the separation of heavy metals from water and wastewater. Biochemical Engineering Journal 2009; 44(1): 19-41. doi: 10.1016/j.bej.2008.12.009.
5. Hou D, He J, Lü C, Ren L, Fan Q, Wang J, et al. Distribution characteristics and potential ecological risk assessment of heavy metals (Cu, Pb, Zn, Cd) in water and sediments from Lake Dalinouer, China. Ecotoxicol Environ Saf 2013; 93: 135-44. doi: 10.1016/j.ecoenv.2013.03.012.
6. Smith AH, Steinmaus CM. Health effects of arsenic and chromium in drinking water: recent human findings. Annu Rev Public Health 2009; 30: 107-22. doi: 10.1146/annurev.publhealth.031308.100143.
7. Brahman KD, Kazi TG, Afridi HI, Naseem S, Arain SS, Ullah N. Evaluation of high levels of fluoride, arsenic species and other physicochemical parameters in underground water of two sub districts of Tharparkar, Pakistan: a multivariate study. Water Res 2013; 47(3): 1005-20. doi: 10.1016/j.watres.2012.10.042.
8. Rajaei Q, Pourkhabbaz AR, Hesari Motlagh S. Assessment of heavy metals health risk of groundwater in Ali Abad Katoul Plian. Journal of North Khorasan University of Medical Sciences 2012; 4(2): 155-62. [In Persian].
9. Sacmacı S, Kartal S, Sacmacı M. Determination of Cr (III), Fe (III), Ni (II), Pb (II) AND Zn (II) ions by FAAS in environmental samples after separation and preconcentration by solvent extraction using a triketone reagent. Fresenius Environmental Bulletin 2012; 21(6): 1563-70.
10. Buschmann J, Berg M, Stengel C, Winkel L, Sampson ML, Trang PTK, et al. Contamination of drinking water resources in the Mekong delta floodplains: arsenic and other trace metals pose serious health risks to the population. Environ Int 2008; 34(6): 756-64. doi: 10.1016/j.envint.2007.12.025.
11. Kumar M, Kumar A, Singh S, Kumar R, Walia TP. Uranium content measurement in drinking water samples using track etch technique. Radiat Meas 2003; 36(1-6): 479-81. doi: 10.1016/S1350-4487(03)00176-8.
12. Argos M, Kalra T, Pierce BL, Chen Y, Parvez F, Islam T, et al. A prospective study of arsenic exposure from drinking

water and incidence of skin lesions in Bangladesh. Am J Epidemiol 2011; 174(2): 185-94. doi: 10.1093/aje/kwr062.
13. Rosado JL, Ronquillo D, Kordas K, Rojas O, Alatorre J, Lopez P, et al. Arsenic exposure and cognitive performance in Mexican schoolchildren. Environ Health Perspect 2007; 115(9): 1371-5.
14. Babaee Y, Alavi Moghadam MR, Ghassemzadeh F, Arbab Zavar MH. Arsenic contamination of groundwater in the Kashmar Koohsorkh. Journal of Environmental Science and Technology 2008; 10(3): 29-36. [In Persian].
15. Farias SS, Casa VA, Vázquez C, Ferpozzi L, Pucci GN, Cohen IM. Natural contamination with arsenic and other trace elements in ground waters of Argentine Pampean Plain. Sci Total Environ 2003; 309(1-3): 187-99. doi: 10.1016/S0048-9697(03)00056-1.
16. Elinge CM, Itodo AU, Peni IJ, Birnin-Yauri UA, Mbongo AN. Assessment of heavy metals concentrations in bore-hole waters in Aliero Community of Kebbi State. Advances in Applied Science Research 2011; 2(4): 279-82.
17. Ghaemi P, Rustami hozori S, Ghaemi A. Determination of copper and lead concentrations in drinking water in Tehran. Journal of Environmental Studies 2004; 30(36): 27-32. [In Persian].
18. Mohammadian M, Nouri J, Afshari N, Nassiri J, Nourani M. Investigation of heavy metals concentrations in the water wells close to Zanjan zinc and lead smelting plant. Iranian Journal Of Health And Environment 2008; 1(1): 51-6. [In Persian].
19. Baptista Neto JA, Smith BJ, McAllister JJ. Heavy metal concentrations in surface sediments in a nearshore environment, Jurujuba Sound, Southeast Brazil. Environ Pollut 2000; 109(1): 1-9.
20. Wang H, Wang CX, Wang ZJ, Cao ZH. Fractionation of heavy metals in surface sediments of Taihu Lake, East China. Environ Geochem Health 2004; 26(2): 303-9. doi: 10.1023/B:EGAH.0000039594.19432.80.
21. Zorer OS, Ceylan H, Dogru M. Determination of heavy metals and comparison to gross radioactivity concentration in Soil and Sediment Samples of the Bendimahi River Basin (Van, Turkey). Water Air Soil Pollut 2009; 196(1-4): 75-87. doi: 10.1007/s11270-008-9758-0.
22. American Public Health Association, American Water Works Association, Water Environment Federation. Standard Methods for the Examination of Water and Wastewater. Washington: APHA, AWWA, WEF; 1999.
23. khorasani N, shaygan J, Karimi Shahri N. a survey of heavy metal concentration in the upper sediment layers of Bandar Abbas coasts. Iranian Journal Natural Research 2005; 58(4): 861-9. [In Persian].
24. Gunduz O, Simsek C, Hasozbek A. Arsenic pollution in the ground water of simav plain, Turkey: its impact on water quality and human health. Water Air Soil Pollut 2010; 205(4): 43-62. doi: 10.1007/s11270-009-0055-3.
25. Mosaferi M,Taghipour H, Hassani AM, Borghei M, Kamali Z, Ghadirzadeh A. Study of arsenic presence in drinking water sources: a case study. Iranian Journal of Health and Environment 2008; 1(1): 19-28. [In Persian].
26. Ho HH, Swennen R, Cappuyns V, Vassilieva E, Neyens G, Rajabali M, et al. Assessment on pollution by heavy metals and arsenic based on surficial and core sediments in the Cam River-mouth, Haiphong province, Vietnam. Soil and Sediment Contamination: An International Journal 2013; 22(4): 415-32. doi: 10.1080/15320383.2013.733445.
27. Nahid P, Moslehi P. Heavy metals concentrations on drinking water in different aeras of Tehran as ppb and methods of remal them. Iranian Journal of Food Science And Technology 2008; 5(1): 29-35. [In Persian].