

Determination of lead in Mashhad city tap water by graphite furnace atomic absorption spectrometry

Naser Vahdati¹, Mahdi Balali-Mood², Alireza Timcheh Hariri², Bamdad Riahi^{2*}

1. Medical Toxicology Research Center, Faculty of Pharmacy, Mashhad University of medical sciences, Mashhad, Iran.
2. Medical Toxicology Research Center, Faculty of Medicine, Mashhad University of medical sciences, Mashhad, Iran.

* Corresponding Author, E-mail: Bamdad_Riahi@yahoo.com

Summary

Lead from drinking water is one of the sources of lead exposure that contributes to the total amount of lead in the body. In this study we measured the lead concentration of tap water in Mashhad city randomly, by graphite furnace atomic absorption spectrometry (GFAAS) technique. The precision of the method was evaluated. The CV% of 6 replicate determinations at 5 µg/l Pb was 3.7 in one day and was 4.5, among 6 consecutive days. The recovery of spiked samples (98.1%) showed that the proposed method is reliable for the determination of trace amounts of lead in water samples. Lead concentration in tap water in the city of Mashhad was 4.27±2.49 µg/l. Although drinking water lead levels of Mashhad is within the standard limit of World Health Organization at present, but the rise of industrialization and their wastes in the margins of the city can make a lot of problems in the long term for drinking water. Therefore, regular estimation of lead and other toxic elements in drinking water is recommended.

Key words: Drinking water, GFAAS, Lead

Introduction

Lead is a toxic heavy metal and can affect many organs in the human body. During the last decades, an extensive data have been published providing a direct link between exposure to low levels of lead and mental deficiency in children. Prolonged intake of even low concentrations of lead can cause serious problems for human health [1].

Measurement of very low levels of environmental pollutants is becoming increasingly important and their monitoring in environmental samples is of major interest [2]. Lead is emitted into the biosphere in considerable amounts, owing to its increased industrial use and its application as a fuel additive [3, 4].

Lead from drinking water is only one of the sources of lead exposure that contributes to the total amount of lead in body. It is the build up of lead from all sources over time that determines whether harmful health effects will occur. Typically, drinking water alone has not been associated with blood lead levels. Combined with other sources, however, the amount of lead from drinking water may be enough to increase the chances of harmful health effects in sensitive individuals, such as infants and children. In recent years concern has increased over the concentration of lead in drinking waters. The European Community (EC) recommends a limit of 50 µg/L of lead in potable waters [5].

Several analytical techniques such as flame atomic absorption spectrometry (FAAS), graphite furnace atomic absorption spectrometry (GFAAS), inductively coupled plasma-optical emission spectrometry (ICP-OES), polarographic analysis and inductively coupled plasma mass spectrometry (ICP-MS) are available for the determination of lead with sufficient sensitivity for most of the applications [7]. GFAAS is one of the most reliable method that we have used for this study.

The tap water in Mashhad is provided from two rivers and 300 wells in margins of city. There are different ways that lead can enter the drinking water, such as from drinking water well contamination of industrial and home waste waters in the areas of the wells or municipal landfill in the margins of city. This study was designed to determine lead concentration of tap waters of different areas in Mashhad city, randomly, by graphite furnace atomic absorption spectrometry (GFAAS) technique.

Experimental

Sampling

After dividing the city into five zones based on the geographical map of Mashhad, 10 samples were taken from each zone randomly. After flowing of the water from the pipe for two minutes, 20ml water was collected in precleaned containers and the pH was adjusted to about 3 with nitric acid. The number of samples was 50 and each sample was performed in triplicate.

Instrumentation

An atomic absorption spectrometer (Perkin-Elmer Model 3030, graphite furnace) was used for all measurements. The hollow cathode lamp for lead was used as the light source. According to the manufacturer recommendation the analytical wavelength, spectral bandwidth and lamp current were 283.3 nm, 0.7 nm and 15 mA, respectively. Carrier gas was argon. The flow of the sample through the column was adjusted. The pressure of argon was adjusted to 3.5–4.0 MPa. A volume of 20 μ l of the final solution was injected into the graphite tube. Temperature was programmed as follows:

Table 1. Temperature programming for determination of lead concentration by graphite furnace atomic absorption spectrometry (GFAAS) technique.

Step	Temperature (°C)	Ramp time (Second)	Hold time (Second)
1	120	20	15
2	400	20	8
3	800	5	5
4	2000	1	2
5	2600	1	1

Reagents

All chemicals were of analytical grade or better. A commercial standard solution of 1000 µg m/L of lead for atomic absorption spectrometry (BDH Ltd) was used as the stock standard solution. Working standard solutions were diluted from the stock standard solution with a 0.1 M nitric acid solution. High-purity water was used throughout the sample preparation, and all the solutions were stored in precleaned polypropylene containers. The materials and vessels used for trace analysis were kept in 10% nitric acid for at least 24 h and subsequently washed four times with ultra-high-quality water before use.

Results and Discussion

The reliability of the method was evaluated by spiking lead into five samples randomly. The recovery results were shown in Table 2. The recovery of spiked samples showed that the proposed method is reliable for the determination of trace amounts of lead in water samples. The precision of the method was also evaluated. The CV% of 6 replicate determinations at 5 µg/l Pb was 3.7 in one day and was 4.5, among 6 consecutive days. The calibration curve for lead had an R^2 value of 0.9978, and is therefore also a good representation of the linearity Beer's Law plot (Figure 1). Lead concentrations in different areas of Mashhad were shown in table 3.

Table 2. Determination of lead in five spiked water samples for recovery test

Area water sample	Added ($\mu\text{g/l}$)	Measured ($\mu\text{g/l}$)	Recovery (%)
1	0	1.1	96.3
	10	10.7	
11	0	4.2	97.8
	10	13.9	
21	0	2.9	102.3
	10	13.2	
31	0	6.8	98.2
	10	16.5	
41	0	5.7	96.1
	10	15.1	
Mean			98.1

Data shown are mean values each sample run in triplicate.

Table 3. The lead concentrations drinking waters in different areas of Mashhad.

Area No.	Pb ($\mu\text{g/l}$)	Area	Pb ($\mu\text{g/l}$)
1	1.1	26	6.2
2	1.8	27	2.2
3	2.7	28	6.8
4	2	29	8.8
5	1.2	30	4.5
6	3.2	31	6.8
7	3.2	32	4.5
8	1	33	3.4
9	4.7	34	8
10	1.2	35	3.9
11	4.2	36	2.2
12	2	37	10.1
13	1.9	38	3.9
14	4.1	39	1.1
15	3.1	40	6.5
16	4	41	5.7
17	2.2	42	1.1
18	4.3	43	4.5
19	3.3	44	7
20	1.7	45	7.9
21	2.9	46	3.6
22	9.7	47	4.1
23	4.8	48	9.6
24	7.3	49	2
25	4.5	50	5.8

Data shown are mean values each sample run in triplicate.
 Mean \pm SD of lead concentration of whole areas was $4.27 \pm 2.49 \mu\text{g/l}$.

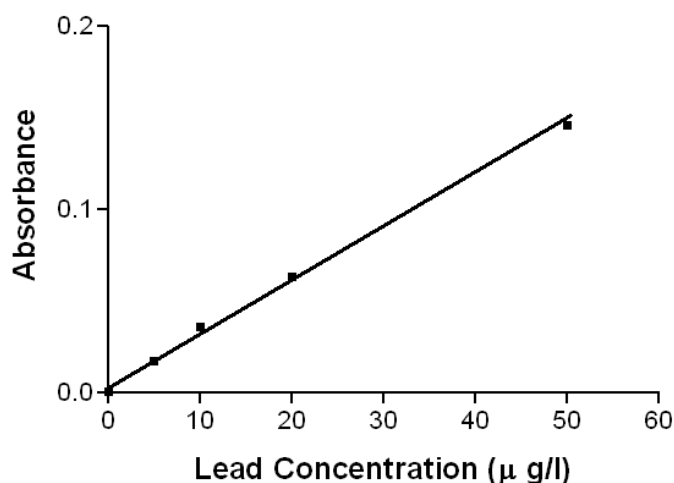


Figure 1. The calibration curve for lead standards. $y = 0.0028x + 0.0036$, $R^2 = 0.9978$. The CV% of 6 replicate determinations at 5 µg/l Pb was 3.7 in one day and was 4.5, among 6 consecutive days.

The overall lead concentration in tap water in the city of Mashhad was $4.27 \pm 2.49 \mu\text{g/l}$. Domain of lead varied from 1 µg/l in Sayyad-Shirazi area to 10.1 µg/l in Tabarsi area. Given the maximum allowable concentration of lead in drinking water according to the Iranian national standard institute guideline, WHO and EC recommendation is 50 ppb [5, 13], now, the amount of lead in tap water in Mashhad is within the standard limit.

The observed differences in lead concentrations among the areas could be due to type of piping system and origin of area water with different drinking water wells. The amount of lead dissolved from the plumbing system depends on several factors, including the presence of chloride and dissolved oxygen, pH, temperature, water softness and standing time of the water. The soft and, acidic water being the most plumbosolvent [6, 7]. In Glasgow (Scotland), where the water was known to be plumbosolvent, the lead concentration in about 40% of the samples exceeded 100 µg/l [8].

In 1988, it was estimated that a lead level of 5 µg/l was exceeded in only 1.1% of public water distribution systems in the USA [9]. A more recent review of lead levels in drinking-water in the USA found the geometric mean to be 2.8 µg/l [10]. The median level of lead in drinking water samples collected in five Canadian cities was 2.0 µg/l [11]. A recent study in Ontario (Canada) found that the average concentration of lead in water actually consumed over a 1-week sampling period was in the range 1.1–30.7 µg/l, with a median level of 4.8 µg/l [12]. In the United Kingdom in 1975–1976, there was virtually no lead in the drinking-water in two thirds of households [13].

By comparing the Mashhad with these areas, we see that drinking water lead levels in this city like other cities of the world is normal. With regard to eliminate the biggest factor lead pollution of the fuel cars (lead tetraethyl) in Iran and also using non- lead water pipelines, this amount of lead measurements is justifiable.

Conclusion

Although drinking water lead concentrations of Mashhad in the present situation is within the standard limits, the rise of industrial towns and factories and their wastes in the margins of the city can make a lot of problems in the long term for dinking water. Therefore, regular estimation of lead and other toxic elements in drinking water of Mashhad is recommended.

Acknowledgements

The authors are thankful to the Vice Chancellor of Research, Mashhad University of Medical Sciences for the financial support.

References

1. Rosen JF. Adverse health effects of lead at low exposure levels: trends in the management of childhood lead poisoning. *Toxicology* 1995; 97:11-17.
2. Chisholm JJ. Lead poisoning. *Sci Am* 1971; 224:15-23.
3. Lynarn DR, Plantanido LG, Cole JF. *Environmental Lead*; Academic Press: New York. 1975.
4. Dadfarnia S, Haji Shabani AM, Dehgan Shirie H. Determination of Lead in Different Samples by Atomic Absorption Spectrometry after Preconcentration with Dithizone Immobilized on Surfactant-Coated Alumina. *Bull Korean Chem Soc* 2002; 23:545-548.
5. Analytical Quality Control (Harmonised Monitoring) Committee. *Analyst* 1985; 110:1-8.
6. Schock MR. Understanding corrosion control strategies for lead. *J Am Water Works Assoc* 1989; 81:88-100.
7. Schock MR. Causes of temporal variability of lead in domestic plumbing systems. *Environ Monit Assess* 1990; 15(1):59-82.
8. Sherlock JC, Quinn MJ. Relationship between blood lead concentrations and dietary lead intake in infants: the Glasgow Duplicate Diet Study 1979-1980. *Food addit contam* 1986; 3:167-176.
9. US Environmental Protection Agency. National primary drinking water regulations for lead and copper. *Federal register* 1988; 53:31515-78.
10. Levin R, Schock MR and Marcus AH. Exposure to lead in U.S. drinking water. In: *Proceedings of the 23rd Annual Conference on Trace Substances in Environmental Health*. Cincinnati, OH, US Environmental Protection Agency. 1989.
11. Dabeka RW, McKenzie AD, Lacroix GMA. Dietary intakes of lead, cadmium, arsenic and fluoride by Canadian adults: a 24-hour duplicate diet study. *Food addit contam* 1987; 4:89-101.
12. Department of National Health and Welfare (Canada). *Guidelines for Canadian drinking water quality: supporting documentation*. Lead. Ottawa. 1992.
13. WHO. *Lead in drinking water: Guidelines for drinking water quality*, 2nd ed, Vol 2, Geneva. 1996.