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Nitrate Intake from Drinking Water in Isfahan in 2004

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Abstract

Drinking water is the fastest and most direct form of nitrate consumption by the population. High concentrations of nitrate in drinking water can be hazardous to health, especially for infants and pregnant women. Nitrate contamination of drinking water is endogenously reduced to nitrite and subsequent nitrosation reactions give rise to carcinogenic N-nitroso compounds. The objective of this study was to determine the quantities of NO_3^- in the consuming drinking water in Isfahan. In this study, 513 water samples were collected from different houses from municipalities of three different zones of Isfahan. Each house was sampled five times during July, August and September of 2004. The average Nitrate concentration for the total samples was 22.8 ± 10.4 mg/L. Nitrate concentrations ranged from 6.6 to 63.5 mg/L. Nitrate concentrations exceeded the maximum contaminant level of 45 mg/L in 19 water samples (3.7%), whereas 332 samples (64.7%) had nitrate concentrations of less than 25 mg/L. There was a significant difference between three zones for monitoring nitrate with averages 16.4 ± 4.9, 18.7 ± 8.9 and 31.2 ± 8.7 mg/L for zone 1, 2 and 3 respectively. Based on results of this study, with one unremarkable exception, the nitrate levels found in the water analyzed were optimum for human consumption and complied with WHO and current European Legislation.

Keywords: Nitrates intake; Pollution resource; Acceptable daily intake; Drinking water

1. Introduction

Human nitrate consumption is an issue of great toxicological concern, since nitrates are involved in the origin of highly toxic compounds such as; nitrites and nitrosamines [1,2]. Nitrate can be reduced to nitrite in water and produce nitrosamines [3,4]. It has been reported that drinking water becomes contaminated with nitrates when rain and irrigation water wash through soils that have been treated excessively with nitrated

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fertilizers [5-7]. High concentrations of nitrate in drinking water can be hazardous to health and may be carcinogen, especially for infants and pregnant women [8,9]. According to the FAO/WHO, standards acceptable daily intake (ADI) for nitrate is less than 3.7 mg/kg/day. Because the effect of this anion increases when the water is used in baby food, the FAO/WHO recommended level for children under three months of age is much lower than ADI for adults [10,11]. This is to the fact that infants are highly susceptible to nitrate induced methemoglobinemia [12,13]. Since the sanitary condition of drinking water is clearly of vital concern for public health this study was undertaken to determine the quantities of NO_3^- in the drinking water of the different Isfahan's municipality divisions. This quantities parameter would be necessary for the assessment of nitrate ADI solely from drinking water.

2. Material and Methods

2.1. Samples

A total of 513 samples were analyzed and collected from the 11 municipal areas of Isfahan city water network in houses simultaneously in five times (July, August, and September of 2004). The number of samples taken in each borough, depended fundamentally on the number of inhabitants (Table 1) and more samples was taken from the most crowded area. Samples were kept in plastic containers and refrigerated until analyzed the day after collection. In order to determine whether there were differences in concentrations between the different geographic areas, Isfahan was divided into three zones, 1, 2 and 3 for south, center and north of Isfahan, respectively. The areas are shaded differently and shown in Figure 1.

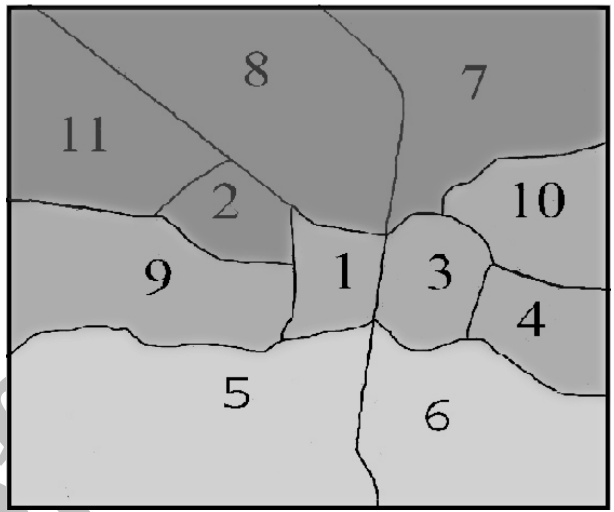

Figure 1. Municipal areas of Isfahan.
Numbers indicate the municipalities of Isfahan according to map of Isfahan. The different shaded areas show the three zones of the city.

Table 1. The number of samples taken in each municipal, average nitrate contents, daily intake and ADI percentage of the drinking water for each municipality

Municipality	**Zone**	**Number of samples**	**Mean ± S.D. (mg/L)**	**Daily intake (mg/L)**	**% of ADI from water**		
					65 kg	70 kg	75 kg
1	2	45	22.5 ± 5.9	45.0	18.7	17.4	16.2
2	3	13	33.4 ± 5.8	66.8	27.8	25.8	24.0
3	2	57	21.2 ± 8.8	42.4	17.6	16.4	15.3
4	2	74	13.0 ± 4.7	26.0	10.8	10.0	9.4
5	1	64	18.0 ± 4.2	36.0	15.0	13.9	13.0
6	1	37	13.7 ± 5.0	27.4	11.4	10.6	9.9
7	3	66	29.8 ± 8.4	59.6	24.8	23.0	21.5
8	3	95	31.8 ± 9.7	63.6	26.5	24.6	22.9
9	2	10	20.6 ± 4.5	41.2	17.1	15.9	14.8
10	2	38	21.2 ± 12.8	42.4	17.6	16.4	15.3
11	3	14	32.2 ± 3.9	64.4	26.8	24.9	23.2
Total		513	22.8 ± 10.4	45.6	19.0	17.6	16.4

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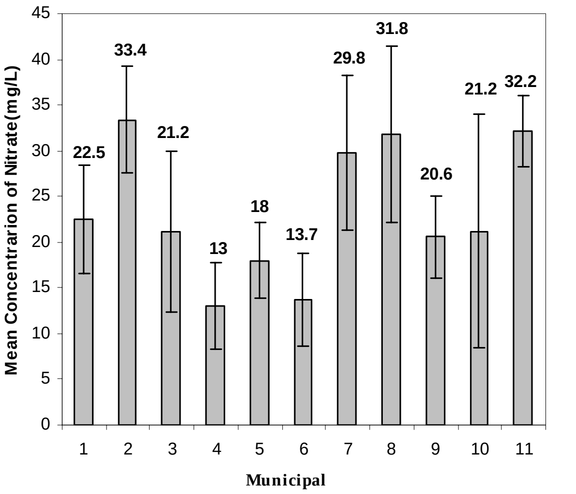

Figure 2. Average nitrate concentrations for each municipality.

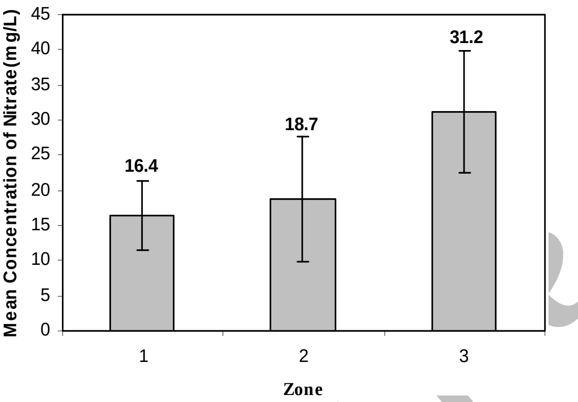

Figure 3. Average nitrate concentrations for each zone.

2.2. Reagents and Standards

All chemicals used were of analytical reagent grade. Standard stock solution containing 1000 mg/L NO_3^- was prepared by dissolving 1.6306 g of KNO_3, after drying at 105°C for 6 h, in one liter deionized water. Working standards, ranging from 1 to 10 mg/L NO_3^-, were prepared by dilution of the stock solution.

2.3. Method of Analysis

Selective ultra-violet Spectrophotometery was used to determine nitrate level [14]. Rapid determination of NO_3^- carried out by measurement of UV absorption (Spectrophotometer Bio-Tek Uvikon 922 with matched silica cells of 1-cm light path) at 220 nm. As dissolved organic matter can also absorb this wavelength, a second measurement at 275 nm was done to correct the NO_3^- value. To prepare the standard curve, a standard nitrate solution of 100 mg/L was diluted to an intermediate dissolution 10 mg/L of NO_3^-. Finally the NO_3^- calibration standards in the range of 1-10 mg/L were prepared. The samples were diluted 1 to 10 by double distilled deionized free NO_3^- water to take the samples NO_3^- content into the range of the standard curve.

Statistical analysis was done with the SPSS Inc. statistics package, Version 9.0.

An ANOVA test was used to determine significant differences between geographic zones.

3. Results and Discussion

Data analysis of each sample concentration was performed, and daily intake and ADI percentages were determined. Table 1 shows the number of samples taken in each municipal, mean of NO_3^- concentrations in mg/L±S.D., and daily intakes. It also shows the percentages of nitrate ADI provided by water for people of three different weights: 65, 70 and 75 kg, respectively. The percentage of nitrate ADI was calculated following FAO/WHO recommendations of 3.7 mg NO_3^-/kg/day and an average water consumption of 2 L [15,16].

The average of nitrate concentration of the 513 of the analyzed sample was 22.8 ± 10.4 mg/L. The Nitrate concentrations ranged from 6.6 to 63.5 mg/L. Nitrate concentrations exceeded the maximum contaminant level (MCL) of 45 mg/L [17,18] in 19 samples (3.7%). These samples were collected from the four municipalities 2, 7, 8 and 11 of zone 3 (see Fig. 2), where the average nitrate concentration was notably higher than the other zones. However, the nitrate concentrations in 332 samples (about 65%) were less than 25 mg/L.

The results can be seen in Figure 3, which shows that there was a significant difference between three zones for monitoring nitrate with averages 16.4 ± 4.9, 18.7 ± 8.9 and 31.2 ± 8.7 mg/L for zone 1, 2 and 3 respectively ($p < 0.05$). With regard to the ADI of nitrate from the drinking water for a person in all weights, this study shows that ADI did not exceed the maximum acceptable level of 45 mg/L. We should point out that only four municipalities exceeded 20% ADI. These were municipalities, 2, 7, 8 and 11, all of which are in zone 3.

The results for zones are presented in Table 2. There is a significant difference between three zones for monitoring nitrate with mean±SD of 16.4±4.9, 18.7±8.9 and 31.2±8.7 mg/L for zone 1, 2 and 3, respectively ($p < 0.05$). Concentrations in zones 1 and 2 were approximately half of that recorded for the zone 3 (Fig. 3).

The lowest levels were detected in some of the municipalities in the south of the Isfahan: municipal 4 and 6 with 13.0 and 13.7 mg/L, respectively.

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Table 2. Mean nitrate contents, daily intake and ADI percentage of houses drinking water for each zone of Isfahan

Zone	Concentration	Daily intake	% ADI		
			65 kg	70 kg	75 kg
1	16.42±4.92	32.86±9.84	13.66±4.09	12.69±3.80	11.84±3.55
2	18.72±8.86	37.44±17.72	15.57±7.37	14.45±6.84	13.49±6.39
3	31.21±8.73	62.43±17.47	25.96±7.26	17.64±8.03	22.50±6.30
F-ratio	157.613	157.613	157.613	157.613	157.613
p	<0.001	<0.001	<0.001	<0.001	<0.001
DF	2, 512	2, 512	2, 512	2, 512	2, 512

The differences with $p < 0.001$ are statistically significant as compared in three zones

4. Conclusion

Based on the results, all the municipalities of Isfahan comply with WHO and current European Legislation on the quality of drinking water destined for human consumption [15]. International Standards for drinking water recommends a limit of 10 mg Nitrogen of NO_3/L (45 mg NO_3^-/L) of nitrate in water to be consumed by nursing infants. The highest concentrations found in the drinking coincided with the north of Isfahan-municipal areas 2, 7, 8 and 11 of the zone 3. However except 19 samples which exceeded the MCL, the contamination of other samples recorded were less than the MCL. It is probable that the drinking water in these four municipalities of zone 3 is the mixture of water network and water wells. The latter is the cause of high NO_3^- content in the mixture. This suggestion is consistent with previous report [5-7].

Acknowledgments

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References

1. Risch H.A. Etiology of pancreatic cancer, with a hypothesis concerning the role of N-nitroso compounds and excess gastric acidity. *Journal of the Natinal Cancer Institute*, **95**(13): 948-960 (2003).
2. Weyer P.J., Cerhan J.R., Kross B.C., Hallberg G.R., Kantamneni J., Breuer G., Jones M.P., Zheng W., and Lynch C.F. Municipal drinking water nitrate level and cancer risk in older women: The Iowa Women's Health Study. *Epidemiology*, **12**(3): 327-338 (2001).
3. Gulis G., Czompolyova M., and Cerhanw J.R. An ecologic study of Nitrate in municipal drinking water and cancer incidence in Trnava District, Slovakia. *Environmental Research*, Section A, **88**: 182-187 (2002).
4. Coss A., Cantor K.P., Reif J.S., Lynch C.F., and Ward M.H. Pancreatic cancer and drinking water and dietary sources of nitrate and nitrite. *American Journal of Epidemiology*, **159**(7): 693-701 (2004).
5. Babiker I.S., Mohamed M.A.A., Terao H., Kato K., and Ohta K. Assessment of groundwater contamination by nitrate leaching from intensive vegetable cultivation using geographical information system. *Environment International*, **29**(8): 1009-1017 (2004).
6. Borken W. and Matzner E. Nitrate leaching in forest soils: an analysis of long-term monitoring sites in Germany. *Journal of Plant Nutrition and Soil Science-*Zeitschrift Fur Pflanzenernahr Ung Und Bodenkunde, **167**(3): 277-283 (2004).
7. Kladivko E.J., Frankenberger J.R., Jaynes D.B., Meek D.W., Jenkinson B.J., and Fausey N.R. Nitrate leaching to subsurface drains as affected by drain spacing and changes in crop production system. *Journal of Enviromental Quality*, **33**(5): 1803-1813 (2004).
8. Criss R.E. and Davisson M.L. Fertilizers, water quality, and human health. *Enviromental Health Perspectives*, **112**(10): A536-A536 (2004).
9. Addiscott T.M. and Benjamin N. Nitrate and human health. *Soil Use and Management*, **20**(2): 98-104 (2004).
10. Fawell J. and Nieuwenhuijsen M.J. Contaminants in drinking water. *British Medical Bulletin*, **68**: 199-208 (2003).
11. Knobeloch L., Salna B., Hogan A., Postle J., and Anderson H. Blue babies and nitrate contaminated well water. *Enviromental Health Perspectives*, **108**(7): 675-678 (2000).
12. Avery A.A. Infantile methemoglobinemia: Reexamining the role of drinking water nitrates. *Ibid.*, **107**(7): 583-586 (1999).
13. Fewtrell L., Drinking-water nitrate, methemoglobinemia, and global burden of disease: A discussion. *Ibid.*, **112**(14): 1371-1374 (2004).
14. American Public Health Association, American Water Works Association, Water Pollution Control Federation (APHA, AWWA, WPCF). Metodos normalizados para el analisis de aguas potables y residuales. Diaz de Santos.Madrid, pp. 4-2, 4-3, 4-145-4-161 (1992).
15. World Health Organization (W.H.O.). Technical Report Series 859. Evaluation of certain food additives and contaminants, 44th Report of Joint FAO/OMS Expert Committee on Food Additives (1996).
16. WHO International standards for drinking water. 3rd Edition, Geneva (1972).
17. Caballero Mesa J.M., Rubio Armendariz C., and Hardisson de la Torre A. Nitrate intake from drinking water on Tenerife Island (Spain). *The Science of the Total Environment*, **302**: 85-92 (2003).
18. Hudak P.F. Regional trends in nitrate content of Texas groundwater. *Journal of Hydrology*, **228**: 37-47 (2000).

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