OCCURRENCE OF FLUORIDE IN GROUNDWATER OF ZARAND REGION, KERMAN PROVINCE, IRAN

Reza Derakhshani,[a] Morteza Tavallaie,[b] Maryam Raoof,[c,g] Tayebeh Malek Mohammadi,[d] Ahmad Abbasnejad,[e] Ali Akbar Haghdoost[f]

Kerman, Iran

SUMMARY: The fluoride (F) content and distribution pattern of groundwater, the main drinking water source, in 35 villages and towns in the Zarand area in Kerman Province of Iran were assessed using the F ion chromatography method. The average groundwater F concentration was 1.80 mg/L (range: 0.33–3.51 mg/L) and in 22 sites the F concentration exceeded 1.5 mg/L, the maximum F drinking water level recommended by the World Health Organization (WHO). Exposure to excess dietary F may lead to chronic disease with detrimental health effects, including dental and skeletal fluorosis, and providing safe water for domestic use is recommended.

Keywords: Dental fluorosis; Distribution pattern; Drinking water; Groundwater; Iran.

INTRODUCTION

Globally, millions of people are affected by the serious problem of fluorosis which is correlated with a high concentration of F ion in drinking water.[1-7] Although the average drinking water F concentration in Iran is relatively low, high levels occur is some areas.[8-10]

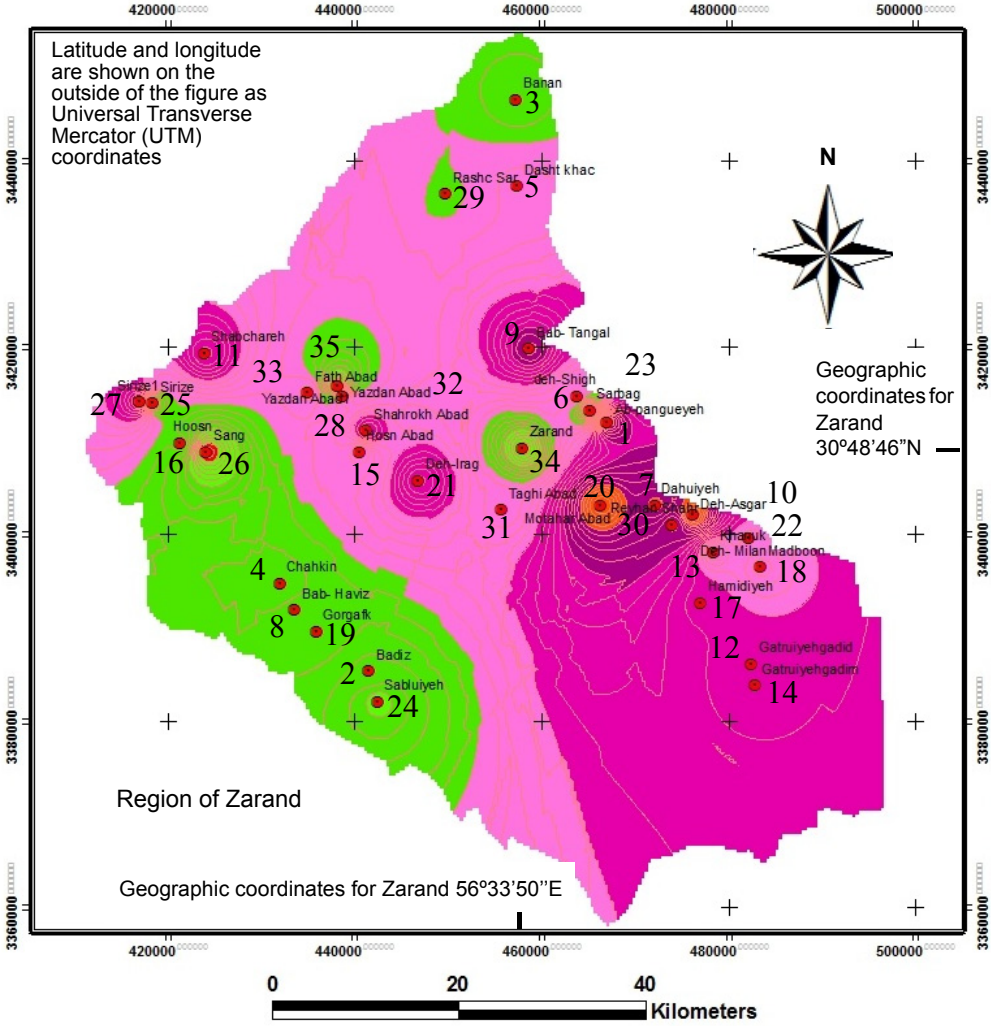
Groundwater is a major source of human intake of F, including its subsequent incorporation into food and beverage items. The excessive intake of F has a negative metabolic effect and may lead to various adverse health effects, both skeletal and non-skeletal, including dental fluorosis, skeletal fluorosis, and neurological complications.[11-16] The amount of F in groundwater is considered to be a function of many factors such as solubility and availability of F minerals in rocks,[17] composition of the host rock through which the groundwater has flowed, velocity of flowing water, pH, temperature, concentration of bicarbonate and calcium ions in water[18] and characteristics of the aquifer.[19, 20]

Despite the importance of the subject, the study in Iran of groundwater F levels[21-3] and the relationship between F levels and dental decay,[29, 31] has been done in only a limited part of the country. In the only groundwater F study done in Zarand, an area in the Central Iran Zone notable for dental fluorosis, Poureslami et al.[32] evaluated the groundwater F content only within the city of Zarand (30º48’46”N, 56º33’50”E). In the present study we assessed groundwater F from villages and towns in a wider part of the Zarand area.

[a]Assistant Professor, Department of Geology, Shahid Bahonar University, Kerman, Iran; [b]PhD student, Department of Dental Public Health, School of Dentistry, Kerman University of Medical Sciences, Kerman, Iran. [c]Assistant Professor, Department of Endodontics, School of Dentistry, Kerman University of Medical Sciences, Kerman, Iran. [d]Assistant Professor, Kerman Oral and Dental Diseases Research Center, Department of Dental Public Health, School of Dentistry, Kerman University of Medical Sciences, Kerman, Iran. [e]Associate Professor, Department of Geology, Shahid Bahonar University, Kerman, Iran. [f]Professor, Research Center for Modeling in Health, Institute of Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran. [g]Author for correspondence: Dr Maryam Raoof, Department of Endodontics, School of Dentistry, Kerman University of Medical Sciences, Kerman, Iran. E-mail: Maryam.raoof@gmail.com

METHOD

In 35 villages and towns in the Zarand district, groundwater samples were collected from drinking water sources and Qanats, elaborate tunnel systems used for extracting groundwater in dry mountain basins in a sustainable manner (Figure 1).



1: Ab-pangueyeh; 2: Badiz; 3: Banan; 4: Chahkin; 5: Dasht khac; 6: Deh-Shigh; 7: Dahuiyeh; 8: Bab-Haviz; 9: Bab-Tangal; 10: Deh-Asgar; 11: Shabchareh; 12: Gatruiyehgadid; 13: Deh-Milan; 14: Gatruiyehgadim; 15: Hosn Abad; 16: Hoosn; 17: Hamidiyeh; 18: Madboon; 19: Gorgafk; 20: Motahar Abad; 21: Deh-Irag; 22: Khanuk; 23: Sarbag; 24: Sabluiyeh; 25: Sirize; 26: Sang; 27: Sirize1; 28: Shahrokh Abad; 29: Rashc Sar; 30: Reyhan Shahr; 31: Tagi Abad; 32: Yazdan Abad; 33: Yazdan Abad1; 34: Zarand; 35: Fath Abad.

Figure 1. Drinking water F levels in the Zarand region.

Before sampling, the sampling containers, colorless polythene 1L plastic barrels, were dipped into nitric acid for 24 hr, washed with 10% HCl, made clean with tap water, and finally washed with distilled water. At the sampling site, the containers were flushed three times with the water being sampled before the sample was taken. The F content of the groundwater samples were determined by the F ion chromatography method.[33]

RESULTS AND DISCUSSION

The groundwater was free from taste, odour and colour. The F concentrations in the groundwater of the 35 villages and towns of the Zarand region are shown in Table 1, Figure 1, and Figure 2.

Table 1. F level in the drinking water in the 35 villages and towns in the Zarand region

Village or town	F mg/L	Village or town	F mg/L	Village or town	F mg/L
Ab-pangueyeh	3.13	Deh-Milan	1.87	Sirize	0.96
Badiz	1.19	Gatruiyehgadim	2.05	Sang	0.33
Banan	1.32	Hosn Abad	1.51	Sirize1	2.86
Chahkin	1.22	Hoosn	1.44	Shahrokh Abad	2.34
Dasht khac	1.62	Hamidiyeh	2.05	Rashc Sar	1.48
Deh-Shigh	1.7	Madboon	1.64	Reyhan Shahr	2.56
Dahuiyeh	3.05	Gorgafk	1.38	Shahrokh Abad	2.34
Bab-Haviz	1.32	Motahar Abad	3.51	Tagi Abad	1.63
Bab-Tangal	2.73	Deh-Irag	2.52	Yazdan Abad	1.94
Deh-Asgar	3.45	Khanuk	1.59	Yazdan Abad 1	0.39
Shabchareh	2.53	Sarbag	0.59	Zarand	0.53
Gatruiyehgadid	2.01	Sabluiyeh	0.95	Fath Abad	1.75

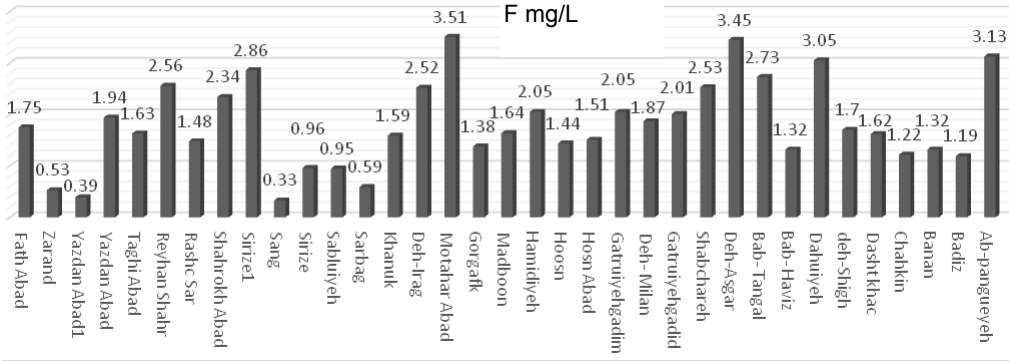


Figure 2. F level in the drinking water in the 35 villages and town in the Zarand region.

The F level in the drinking water had a range of 0.33–3.51 mg/L, a mean of 1.8 mg/L, a median of 1.64 mg/L, a variance of 0.69, a skewness of 0.27, and a SD of 0.83. The lowest F concentration of was observed in the Sang site (0.33 mg/L) while the maximum concentration was recorded from Motahar Abad (3.51 mg/L). In 22 of the villages and towns (63%) the F level was higher than 1.5 mg/L, the maximum level recommended by the World Health Organization (WHO)[34] (Motahar Abad, Deh-Asgar, Ab-pangueyeh, Dahuiyeh, Sirize 1, Bab-Tangal, Reyhan Shahr, Shabchareh, Deh-Irag, Shahrokh Abad, Gatruiyehgadim, Hamidiyeh, Gatruiyehgadid, Yazdan Abad, Deh-Milan, Fath Abad, Deh-Shig, Madboon, Tagi Abad, Dashtkhac, Khanuk, and Hosn Abad)(Table 1, Figure 1, and Figure 2).The remaining 13 villages and towns (37%) had levels below 1.5 mg/L (Rashk Sar, Hosn, Gorgafk, Banan, Bab-Haviz, Chahkin, Badiz, Sirize, Sabluiyeh, Sarbag, Zarand, Yazdan Abad 1, and Sang)(Table 1, Figure 1, and Figure 2).

The F levels in the ground water showed a normal distribution suggesting that natural processes were involved (Figure 3).

The calcium levels of the water were analyzed because fluoride toxicity is increased when calcium levels are very low (Table 2).

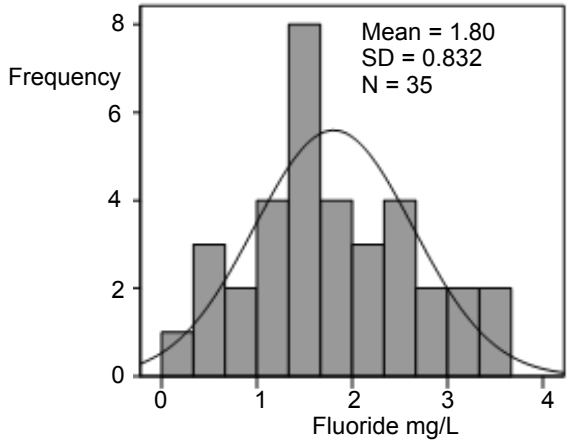


Figure 3. Frequency histogram of fluoride in groundwater in the Zarand region.

Table 2. Ca level in the drinking water in the 35 villages and towns in the Zarand region

Village or town	Ca ppm	Village or town	Ca ppm	Village or town	Ca ppm
Ab-pangueyeh	58	Deh-Milan	34	Sirize	44
Badiz	44	Gatruiyehgadim	66	Sang	38
Banan	74	Hosn Abad	54	Sirize1	286
Chahkin	58	Hoosn	76	Shahrokh Abad	438
Dasht khac	54	Hamidiyeh	34	Rashc Sar	98
Deh-Shigh	100	Madboon	90	Reyhan Shahr	102
Dahuiyeh	116	Gorgafk	30	Shahrokh Abad	96
Bab-Haviz	48	Motahar Abad	60	Tagi Abad	176
Bab-Tangal	156	Deh-Irag	58	Yazdan Abad	22
Deh-Asgar	480	Khanuk	70	Yazdan Abad 1	40
Shabchareh	76	Sarbag	74	Zarand	100
Gatruiyehgadid	38	Sabluiyeh	106	Fath Abad	438

Groundwater is a major source of drinking water in the semi-arid Zarand region, geologically part of the so-called Central Iran Zone. The major strata outcropped there, are Mesozoic strata, which are sedimentary formations, hundreds of m is depth, consisting mainly of sandstone, siltstone, mudstone, some limestone layers, and coal seams. Due to the influence of recurrent faulting and folding, all the sets of strata are multi-repeated outcrops. Paleozoic and Cenozoic strata are valid but not as thick as the Mesozoic ones.

CONCLUSION

Our findings indicate that 63% of the groundwater samples collected from the Zarand area had F levels above 1.5 mg/L, the maximum level recommended by the WHO, and are thus are a serious risk to human health, including for the development of dental fluorosis.[34] To maintain the quality of the ground water, continuous monitoring of the physico-chemical parameters should be done, and when the F level is above 1.5 mg/L it should be treated before being used for cooking and drinking. It is strongly recommended that some immediate work be undertaken in the high F areas to provide water with a safe F content of below 1.5 mg/L by designing and constructing of water reservoir using limestone and lowering the groundwater F content to a safe level before piping the water to residential areas for cooking and drinking purposes. Treatment options include the rapid mixing of water with aluminum sulphate, lime (sodium or calcium carbonate), and bleaching powder. The use of a selective exchange resin has been found to be very effective.[35] Because black tea has a high F content and is a very common drink in this area it is recommended that is should be prepared with low fluoride bottled water.[28, 30]

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