World Applied Sciences Journal 8 (11): 1317-1321, 2010
ISSN 1818-4952

A Study of Fluoride Groundwater Occurrence in Posht-e-Kooh-e-Dashtestan, South of Iran

S. Battaleb-Looie and F. Moore

Department of Earth Sciences, Faculty of sciences, Shiraz university, Shiraz, Iran

Abstract: A study was performed to determine groundwater fluoride concentration of Posht-e-Kooh-e-Dashtestan area located in southern Iran. Groundwater samples were collected from 26 wells, 4 springs, during dry and wet seasons. Fluoride concentration was determined in the water samples using SPADNS method. The results showed that fluoride concentrations are above the World Health Organization (WHO) maximum permissible limit of 1.5 mg/l and fluoride concentration in wet season is higher than its concentration in dry season. 3D fluoride distribution map was prepared in ArcGis 9.2. The result showed that fluoride values are associated with alluvial soils and dolomite that the latter along with gypsum are probable sources of fluoride into water resources. Local population is in the risk of adverse health effects of excessive fluoride intake in long-term and already many show evidence of dental fluorosis. Water treatment and defluoridation are recommended.

Key words: Fluoride · Fluorosis · Groundwater · Posht-e-Kooh-e-Dashtestan · Iran

INTRODUCTION

Fluorine (F) is the most reactive and the most electronegative nonmetal and therefore almost never occurs in nature in its elemental state. Fluorides are mainly found in ground water resulting from the reaction of water with rocks and the soil of the Earth's crust. Fluoride exists in a number of minerals among which fluorspar, cryolite and fluorapatite are the most common. Fluoride is an essential trace element for human body and ingestion mainly takes place through drinking water. Major sources of fluoride in water are fluoride-bearing minerals in rocks and anthropogenic sources including industries that manufacture biosides, fertilizers and aluminum [1, 2]. A lot of work has been done to understand the source and origin of high-fluoride bearing groundwater [3-7].

Although optimum levels of fluoride has beneficial effects on teeth and reduces dental caries, high or low levels of fluoride mainly in drinking water have been found to cause adverse health effects including dental and skeletal fluorosis. High concentration of fluoride (above 4 mg/L) in potable water result in teeth mottling and skeletal fluorosis whereas low levels (below 1 mg/L) result in diminishing caries reduction [8, 9]. Fluorosis is endemic in many developed and developing countries such as U.S.A., Australia, China and india [10-13]. The main objectives of this research are:

- To determine fluoride concentration in groundwater in the study area.
- To evaluate the seasonal variation of fluoride concentration.
- To explore the connection between fluoride concentration and lithology.

Geology of the Study Area: The study area is situated in the southeastern part of Bushehr Province, South of Iran. It covers approximately 3000 km2 and is bounded by the latitudes 28°40′ (3172352 Utm) N and 29°30′ (3259939 Utm) N and longitudes 51°15′ (531562 Utm) E and 51°45′ (586289 Utm) E (Fig. 1). The area has dominantly two seasons; a short rainy season with moderate temperatures and a long dry season with high temperatures. The climate is arid with average maximum and minimum temperatures being 47.5°C to 8.29°C respectively. Annual mean precipitation is about 270 mm. Lithologically the area is characterized by folded and faulted carbonatic (limestone and dolomite), evaporatic (gypsiferrous) and conglomeratic formations. In the Posht-e-Kooh-e-Dashtesan area groundwater is used both for drinking and irrigation.

Corresponding Author: S. Battaleb-Looie, Department of Earth Sciences, Faculty of sciences, Shiraz university, Shiraz, Iran Tel/Fax: +987112284572

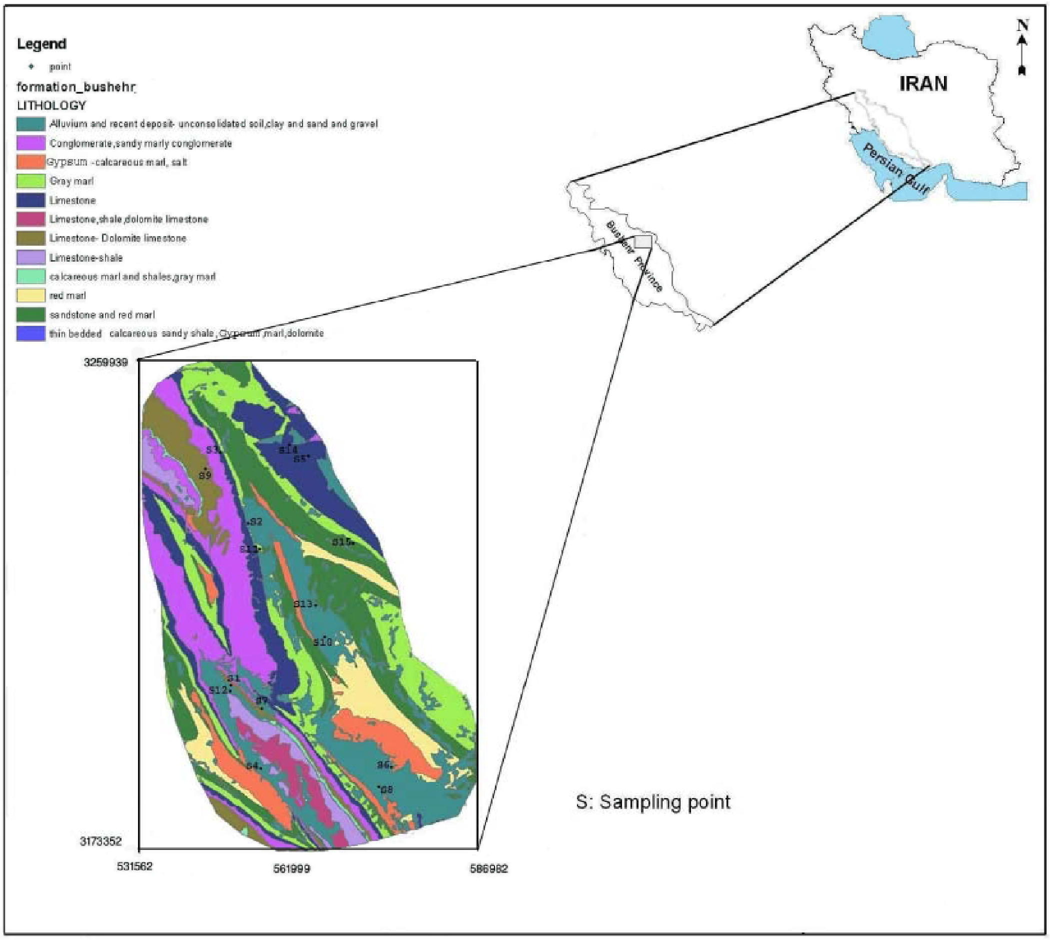

Fig. 1: Geology map of the study area and the locations of the sampling points

MATERIALS AND METHODS

The sampling points were first registered using Global Positioning System (GPS) and are reported in Universal Transverse Mercator (UTM) coordinates. Water samples were collected in 1.0 liter plastic bottles (previously washed with deionised water and 2 times with water to be sampled) from 30 sampling sites including 28 wells and 2 springs during dry and wet months. The dry season samples were taken from 15 water sources in July. Wet season samples were taken from the same sampling points in January in order to evaluate seasonal variation of fluoride concentration in the area. The samples were analyzed in the hydrogeological laboratory of water and wastewater organization of Bushehr province. Fluoride was analyzed using the SPADNS colorimetric method. This Method of fluoride determination involves reaction of fluoride with a red zirconium-dye solution. Fluoride combines with part of the zirconium to form a colorless complex, thus bleaching the red color in an amount

Table 1: Fluoride concentrations of sampling points in wet and dry season. Well (w), Spring (s)

	Fluoride concentration	
Sampling points	Rainy season	Dry season
S1: Shaldan(w)	2.03	1.69
S2: Chah-khun(w)	3	2.01
S3:Emam-zadeh(w)	1.22	1.2
S4:Dehrud-e-sofla(w)	6.6	4.9
S5:Dehrud-e-olya(w)	4.3	3.6
S6:Porchunak(w)	4.3	2.7
S7:Tang-e-eram(w)	4.15	2.09
S8:Kaftaru(s)	3.7	1.6
S9:Talkhab(w)	2.19	0.97
S10:Rud-e-faryab(w)	3.65	2.13
S11:Tang-e-faryab(w)	1.17	0.7
S12:Cheshmey-e-kheyrak(s)	3.9	2.1
S13:Talhe(w)	1.8	0.9
S14:Tang-e-zard(w)	4.3	1.58
S15:Tang-e-zard-e-jadid(w)	3.4	1.59

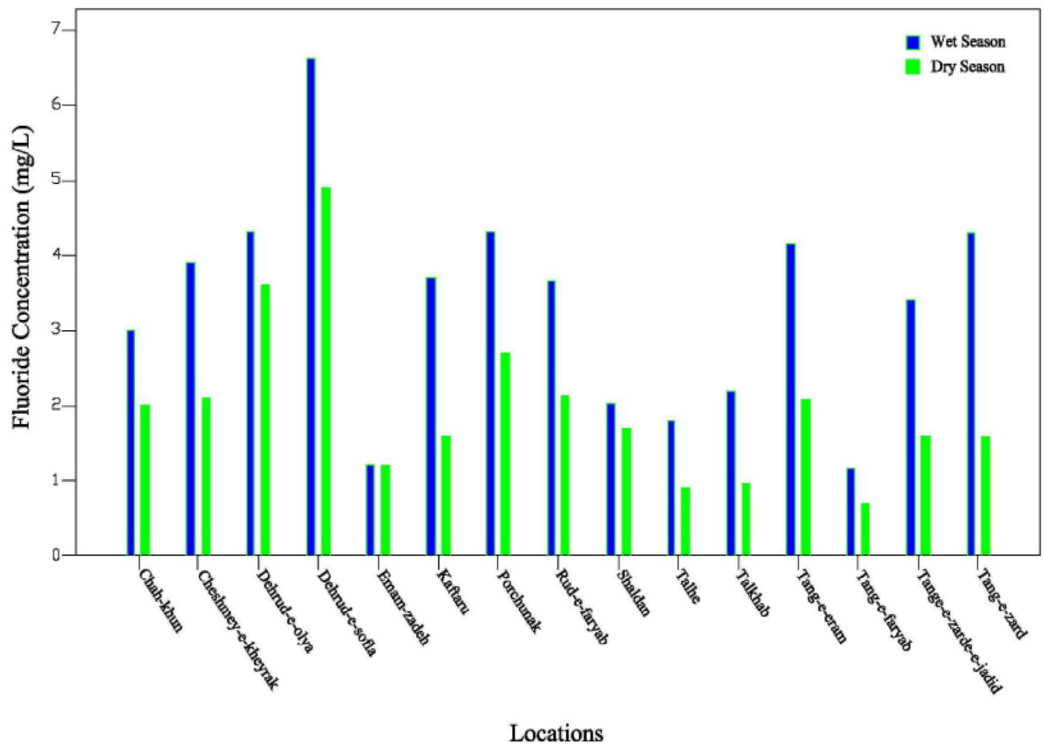

Fig. 2: Fluoride concentration of water samples in wet and dry seasons

proportional to the fluoride concentration. A calibration standard ranging from 0 to 0.4 mg F-/L was prepared by diluting an appropriate volume of standard fluoride solution. 10.0 ml the SPADNS reagent was added to 50 ml of standard solution and thoroughly mixed. A spectrophotometer was set at wavelength of 570 nm. A calibration graph was prepared from different standard F- concentrations [14].

The locations of the sampling points and fluoride concentrations are shown in Figs 1 and 2 respectively. Table 1 gives concentration of fluoride in dry and wet season for each sampling points in Figs 1 and 2 (Table 1).

RESULTS AND DISCUSSION

Results for the Dry Season (July 2005) and the Wet Season (January2005): Fig. 2 shows the fluoride concentration in water samples in the dry (July) and wet (January) seasons. Fluoride concentration in wet season in all samples is higher than those of dry season.

Fig. 3 shows the average fluoride concentrations in dry and wet seasons. Average fluoride values in wet season (3.3 mg/l) are higher than the dry season (1.9 mg/l). Fig. 4 displays percentage of the number of analyzed samples that fall within different fluoride concentration ranges. Fluoride concentration in the dry season ranges from >0.7 to 4.9 mg/l. 12 samples had above 1.5 mg/l fluoride content. This indicates that 73.2% of water samples have fluoride content above WHO maximum permissible level (1.5 mg/l).

The results of wet season ranges from >0.97 to 6.6 mg/l, with fluoride concentration in 13 samples being over 1.50 mg/l indicating that 86.6% of the water samples had fluoride concentration above the WHO maximum permissible level of 1.5 mg/l.

Fig. 4 indicates that the concentration of fluoride in wet season (more than 3 mg/l) is much higher than that of fluoride in dry season that is 60% of water samples in wet season have concentrations higher than 3 mg/l while 13.2% of water samples in dry season have similar concentration (Fig. 4).

3D Fluoride Distribution Map: 3D distribution maps for fluoride concentrations in the wet and dry seasons were separately prepared by ArcGis 9.2 (Figs. 5a and 5b respectively). According to the 3D map for the wet season (Fig.5a), the high concentrations of fluoride occur in high elevations (alluvial soils and limestone). It has been suggested that weathering and decomposition of fluoride bearing minerals such as gypsum can release fluoride into

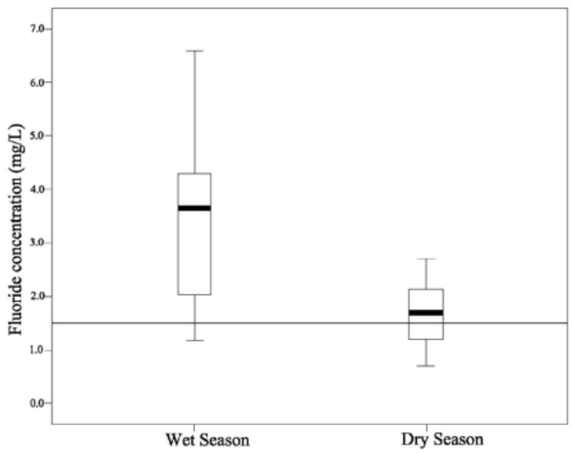

Fig. 3: Box plot of fluoride concentration in wet and dry seasons (line shows the permissible limit of F)

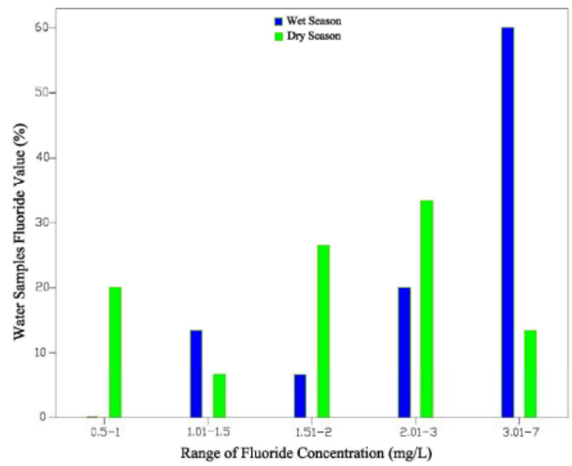

Fig. 4: Ranges of fluoride concentration in wet and dry seasons

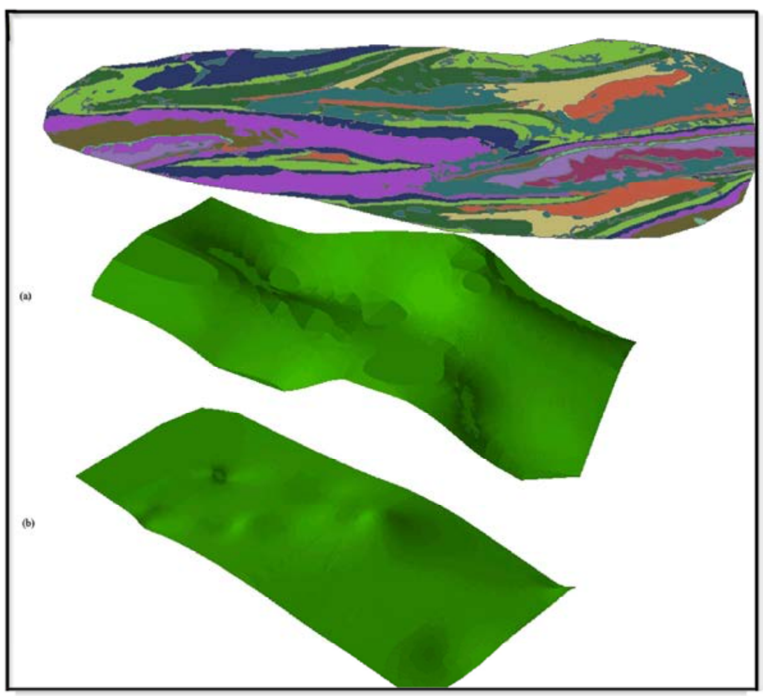

Fig. 5: 3D distribution map of fluoride in wet season and dry season (a,b).

water resources [15]. Also according to Kabata-Pendias and Pendias [16] occurrence of fluorite (CaF2) in limestone and fluoride as fissure veins can release appreciable quantities of fluoride in the environment similar veins are seen to occur in Posht-e-Kooh-e-Dashtesan area and are believed to contribute to fluoride concentrations.

The 3D fluoride distribution map for dry season shows that the high concentrations of fluoride occur in high elevation (alluvial soils, dolomite and limestone). However most are located on alluvial soils (Fig. 5b).

CONCLUSION

This is the first report on the fluoride occurrence in south of Iran. Plotting sampling points on the geological maps together with 3D fluoride distribution maps in the wet and dry seasons shows that dolomite and limestone along with gypsum are likely sources of fluoride in the Posht-e-Kooh-e-Dashtesan area. Comparing fluoride concentration in dry and wet seasons indicates higher concentrations in the latter probably reflecting higher leaching of fluoride and the resulting fluoride enrichment. Educating local population and water treatment facilities for reducing fluoride concentration is recommended to avoid longterm effects of high fluoride concentration. Although this study indicates that fluoride concentration in spring water is high, the local populations believe that drinking from springs is safer and this misbelief increases the adverse health effects of high fluoride concentrations. Many people in the area show evidence of dental fluorosis with few cases of severe occurrences.

ACKNOWLEDGMENT

We thankfully acknowledge the assistance Mrs Hamidian, laboratory manager of the water and wastewater organization of Bushehr Province, who has provided the necessary materials to carry on this study. Thanks are also extended to Shiraz university research committee.

REFERENCES

1. Apambire, W.M., D.R. Boyle and F.A. Michel, 1997. Geochemistry, genesis and health implications of fluoriferous groundwaters in the upper regions of Ghana. Environmental Geol., 35: 13-24.
2. Chadha, D.K. and S.R. Tamta, 1999. Occurrence and origin of groundwater fluoride in phreatic zone of Unnao district, Uttar Pradesh. J. Applied Geochemistry 1: 21-26.
3. Banks, D., C. Reimann, O. Royset, H. Skarphagen and O.M. Saether, 1995. Natural concentrations of major and trace elements in some Norwegian bedrock groundwaters. Applied Geochemistry 10: 1-16.
4. Gizaw, B., 1996. The origin of high bicarbonate and fluoride concentrations in waters of the main Ethiopian Rift Valley. J. African Earth Sci., 22: 391-402.
5. Carrillo-Rivera, J.J., A. Cardona and W.M. Edmundus, 2002. Use of abstraction regime and knowledge of hydrogeological conditions to control high fluoride-concentration in abstracted groundwater: San Luis Potosi basin, Mexico. J. Hydrol., 261: 24-47.
6. Shanker, R., J.L. Thussu and J.M Prasad, 2003. Geothermal studies at Tattapani hot spring area, Sarguja district, central India. Geothermics, 16: 61-76.
7. Msonda, K.W.M., W.R.L. Masamba and E. Fabiano, 2007. A study of fluoride groundwater occurrence in Nathenje,Lilongwe, Malawi. Physics and Chemistry of the Earth, 32: 1178-1184.
8. Abdulrahmani, A., 1996. Fluoride content in drinking water supplies of Riyadh, Saudi Arabia, Environmental Monitoring and Assessment, 48: 261-272.
9. Jenkins, G.N., 1978. The Physiology and Biochemistry of the Mouth, Blackwell Scientific Publications, London, pp: 466.
10. Grimaldo, M., V.H. Borja-Aburto, A.L. Ramírez, M. Ponce, M. Rosas and F. Diaz-Barriga, 1995. Endemic fluorosis in San Luis Potosí, Mexico. Environmental Res., 68: 25-30.
11. Shomar, B., G. Müller, A. Yahya, S. Askar and R. Sansur, 2004. Fluorides in groundwater, soil and infused-black tea and the occurrence of dental fluorosis among school children of the Gaza Strip. J. Water and Health, 2: 23-35.
12. Binbin, W., Z. Baoshan, W. Hongying, P. Yakun and T. Yuehua, 2005. Dental caries in fluorine exposure areas in China. Environmental Geochemistry and Health, 27: 285-8.
13. Grimaldo, M., V.H. Borja-Aburto, A.L. Ramírez, M. Ponce, M. Rosas and F. Diaz-Barriga, 1995. Endemic fluorosis in San Luis Potosí, Mexico. Environmental Res., 68: 25-30.
14. Meenakshi, R.C., Maheshwari, 2006. Fluoride in drinking water and its removal. J. Hazardous Materials, B137: 456-463.
15. Zhang, B., M. Hong, Y. Zhao, X. Lin, X. Zhang and J. Dong, 2003. Distribution and risk assessment of fluoride in drinking water in the west plain region of Jilin Province, China. Environmental Geochemistry and Health, 25: 421-31.
16. Kabata-Pendias, A. and H. Pendias, 2001. Trace elements in soil and plants. Boca Raton, FL: CRC press, pp: 403.