BREIF COMMUNICATION

Geographic Information System for distribution of groundwater fluoride levels in Iranian city of Dehloran

Shima Rezaei[1], Rouhollah Shokri*[2], Rasoul Momenzadeh[3], Ali Jamshidi[4], Razieh Yazdizadeh[5]

1. MSc, Environmental Health Research Center, Kurdistan University of Medical Sciences, Sanandaj, Iran
2. Abadan School of Medical Sciences, Abadan, Iran
3. Graduated Masters, Environmental Health Engineering, School of Public Health, University of Medical Sciences, Kerman, Iran
4. Manager of Water Treatment Plant, Ilam, Iran
5. Graduated of Environmental Pollution, Science and Research Branch, Islamic Azad University, Ahvaz, Iran

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ABSTRACT

Humans are faced with serious problems due to the unfit fluoride levels in potable water, which cause skeletal and dental fluorosis. Therefore, correct information regarding fluoride level in water resources is important in community dentistry, however this data is missing at national level. The aim of this descriptive-analytical study was to explore and map fluoride dispersion patterns of groundwater by Arcview GIS 9.3 software in April 2013 to March 2014 in Dehloran, Ilam County, located in western Iran. Water sampling was carried out on 8 wells which are sources of drinking water. The analytical technique applied for fluoride determination on 96 water samples was spectrophotometry by the SPADNS method according to the standard method. Fluoride concentration changed from 0.24 to 1.03mg/l with a mean of 0.48±0.12 mg/l. Approximately, 0% of the samplesare above 1mg F/L. The appropriate percentage for human consumption limit is about 17.7% of water samples. Although 82.29% of the water samples were having less than the permissible range of 0.6 mg/l, there is a statistically significant relationship between the monthly average fluoride concentrations in each well. However, no significant associations were found between the average fluoride concentrations of different wells in each month.

Key words: Drinking Water, Fluorides, GIS, Ground Water Resources

Introduction

Fluorine as the thirteenth most common element which is extensively dispersed in the lithosphere, is found in multiple forms in nature and water resources (due to its high reactivity, it does not exist in the elemental state in nature). Inorganic compounds of fluorine could be applied to a broad range of object such as phosphate fertilizers, aluminium production, steel and glass fibre industries. It can also enter the environment from other sources such as as bricks, tiles and ceramics.[1] Contamination of water resources by industrial wastewater containing high level of fluoride can lead to toxication in aquatic organisms.[2]

National primary drinking water standard for fluoride is determined based on the annual weather averages and daily maximum air temperature. WHO recommendation was 0.8 and 1.2 ppm for hot and cold months, respectively, based on the average yearly temperature of about15°C.[3] Moreover, Institute of Standards and Industrial Research of Iran proposed a baseline of 0.6 to 1 mg F/l.[3] Fluoride has both useful and damaging property on human health, at the same time. The outbreak in dental caries is reversely linked to the fluoride levels in water resources, in areas deficient in fluorine (less than 0.5 mg/l), and fluorine supplementation can diminish the incidence of dental caries.[4-6]

Rouhollah Shokri
shokrirohhollah@yahoo.com

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There is a dose-response relationshipbetween fluoride level and the outbreak of dental fluorosis (greater than 1.7mg F /l). In a society where there is extremely high levels of fluoride in water and foodstuffs (concentrations above 3.6 mg/l), skeletal fluorosis and bone diseases are the most relevant side effects.[7] Although the whole waters resources contain trace amounts of fluoride, higher levels are related to groundwater. Therefore, regarding the types of rocks, fluoride level reaches 10 mg F/l in areas rich in fluorine-containing mineral. The daily fluoride intake depends on geographical region and sources of exposure.

Fluoride enters the body in several ways, but the important way to get it is through potable water.[3] After oral uptake, because it is a water-soluble metal, fluoride is quickly absorbed in the digestive tract and almost totally and transported through the blood. With continued exposure, fluoride levels are the same in the blood and in potable water. Fluoride distribution and incorporation into hard tissues (bone, tooth) is fast and reversible.[8] Elevated fluoride exposure can lead to learning disabilities, low hemoglobin level, reduced IQ, immunodeficiency and thyroid disorders.[5] Information existing about fluoride concentration are necessary in preventive measures and to the best of our knowledge, no studies have yet been published about fluoride in Dehloran. Given the all the description above , the aim of this study was to map out the fluoride levels by Geographic Information Systems (GIS) software in different drinking water sources of Dehloran, Ilam.[9]

Materials and Methods

This descriptive- analytical study was carried out in April 2013 to March 2014. The main objective was to assess the fluoride level of drinking water in Dehloran, Ilam, located at western Iran. Regarding the groundwater resources, which have been the drinking water resources in this city, we performed our research on well water. Water sampling from 8 wells was done in clean polyethylene bottles, then samples were transported to the laboratory in appropriate conditions.[10] One sample per month was taken from each well for 12 months (Total of 96). The spectrophotometric method for fluoride measurement was carried out on 96 water samples by the SPADNS calorimetric method in the wavelength of 570 nm according to the standard method.[3, 11, 12] Information on different sampling water resources were imported into the Arcview GIS 9.3 software. GIS software helps to produce the spatial distribution of fluoride groundwater pollutants. Then the result was compared with Standard No. 1053 from Institute of Standards and Industrial Research of Iran (0.6 to 1mg F/l) and WHO.[13]Normality of data was assessed in SPSS v. 20 software and the Kruskal-Wallis test as a nonparametric test was used to define whether there is a statistically significant difference between the monthly average fluoride levels of 8 wells and average fluoride concentration of different wells per month.

Results and Discussion

Study location

The areas subjected to this research are defined in Figure 1.

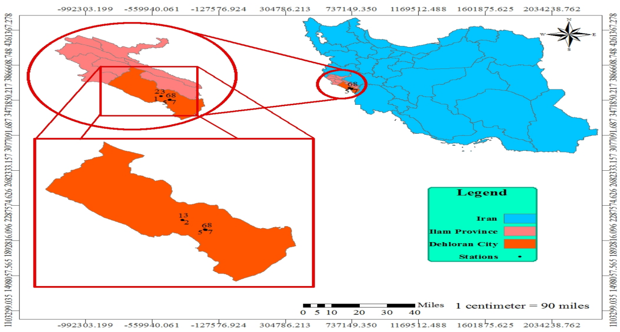

Fig.1 Location of the study sites

The map showing location of study sites. Dashte Akbar 1 named well No. 1, and thus Dashte Akbar 2, Dashte Akbar 3, Bare Bije 1, Bare Bije 2, Bare Bije 3, Bare Bije 4 and Bare Bije 5 are called well No. 2, 3, 4, 5, 6, 7 and 8, respectively. Geographical distribution of average fluoride concentration (mg/L) in different seasons in drinking water resources (8 wells) is presented in Figure 2.

As evident in Fig. 2, these findings imply that the fluorine levels in majority of water sample were less than the guidelines recommended by

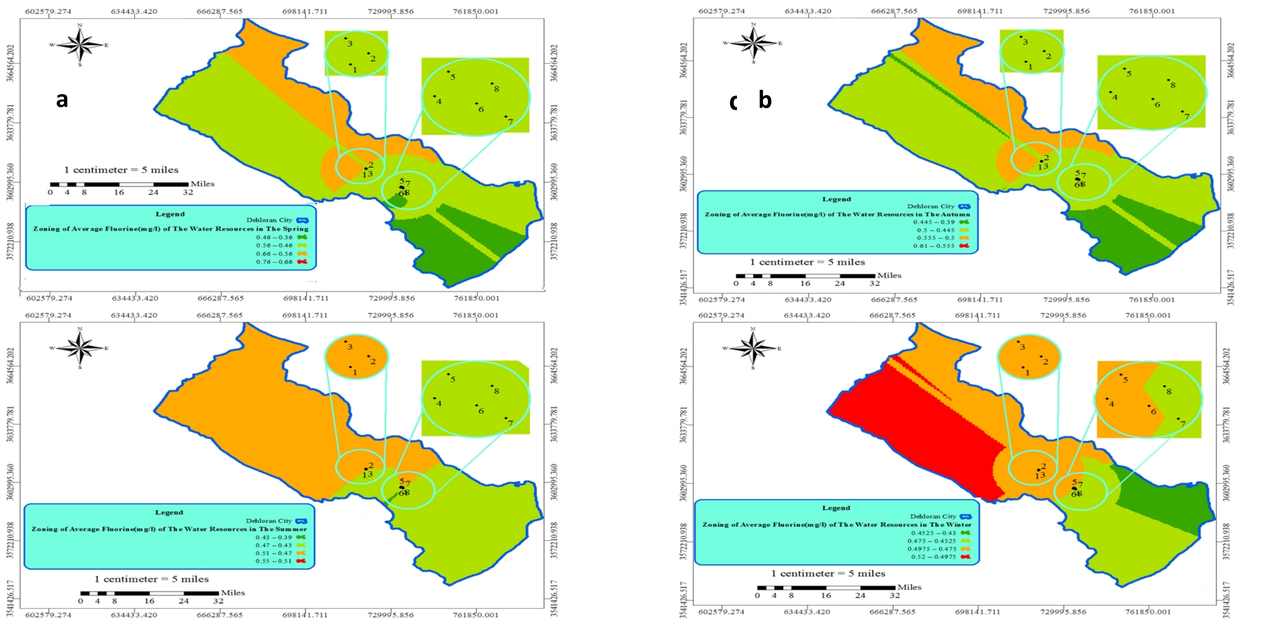

Fig. 2 Zoning average fluorine concentration (mg/L) in the Dehloran drinking water resources, in a: spring, b: summer, c: autumn and d: winter

WHO (0.5-1 mg/l) and Iranian standard (0.6-1), and ranged from 0.24 to 1.03 mg/l with a mean of 0.48±0.12 mg/l. Our results are similar to most previous studies carried out in Sanandaj, Gorgan, Babol and Qom.[3, 14-16] About 17.7% of the drinking water samples were appropriate for human consumption and were in the range of Institute of Standards and Industrial Research of Iran (0.6 to 1mg F/l), and greater than the permissible range (over 1mg F/l) devoted to 0% of the samples. The fluoride content of about 82.29% was identified in the water collected which was less than the permissible range of 0.6-1 mg/L. Moreover, fluoride concentrations in 54% of water samples were less than the standard recommended by WHO. Then, many symptoms like dental caries and osteoporosis can probably develop in consumers as a result of the fluoride deficiency of Dehloran drinking water.

Also, Fig 3 shows the average, maximum and minimum fluoride concentration of Dehloran drinking water sources (mg/L) in (a) different months and (b)variety of wells.

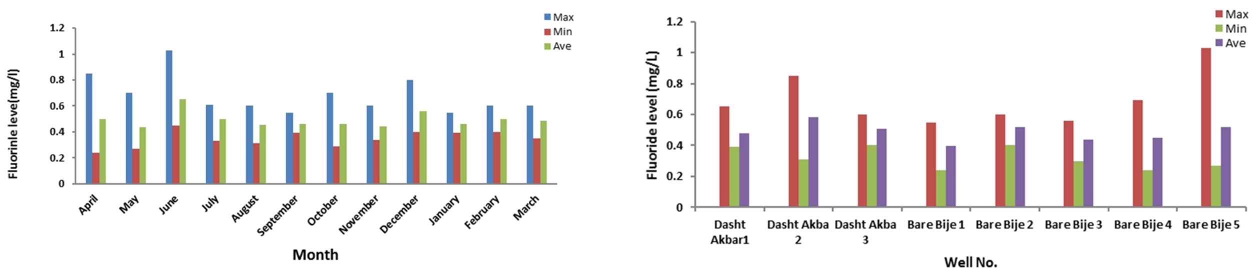

Fig.3 Average, maximum and minimum fluoride concentration(mg/l) of Dehloran drinking water sources in different months (a) and variety wells (b) in 2014

As can be clearly seen in Figure 3, the average value of fluorine level in 75% water samples was less than the minimum recommended WHO standard (0.5 to 1 mg/L).

Galagan suggested proper fluoride level in drinking water depending on the ambient temperature. Based on this, 0.6-0.7 mg F/L has often been recommended as appropriate for tropical countries. In Dehloran city, climatic condition was in tropical condition. Nevertheless, due to high water consumption in tropical countries, difficult dental fluorosis has

been observed. Thus, depending on the climatic conditions and fluoride ingestion from other sources, appropriate fluoride level of drinking water fluctuates from 0.5 to 1mg/l.[9]
Also, in another study, Elango *et al.* classified the fluoride content of groundwater samples into four groups; low (0.1 to 0.6 mg/l), medium (0.6 to 1.5 mg/l), high (1.5 to 3 mg/l), and very high (>3 mg/l).[10] According to this research, the average amount of fluorine in Dehloran drinking water is in the low group.
Interpreting and reporting the results of Kruskal–Wallis H showed that there was no significant difference between the average fluoride levels in different months (P_v =0.206). Also, as a result, the data demonstrate that there is a statistically significant difference (P_v=0. 009) between the monthly average fluoride concentrations in different well water resources. Yousefi *et al.* similarly, showed a significant difference in average fluoride concentration between different seasons. [17] Also, in this area, fluoride level shows significant differences between various Dehloran water resources.
Karegar *et al.* have suggested that fluoride deficiency in water resources can be compensated via the food chain.[15] Their results showed that fluoride level in mountainous regions was lower than the plain areas. For instance, fluoride concentration of Ozone drinking water in mountainous regions was 0.5 -0.7 mg/l. Also, maximum and minimum fluoride content in the Kerman desert city were 1.8 and 0.6 mg/l, respectively.[14, 15] As Dehloran city maintains a warm climate in plain regions, our study was inconsistent with previous findings, which may be linked to soil type.
Ebrahimi *et al.* presented the average fluoride concentration in water resource of Poldasht city and the rural areas was higher than the recommended standards at about 1.77 and 2.11 mg/L, respectively.[18] This is inconsistent with our results. Zou et al. reported children as a vulnerable population in most of the studied fluorosis areas and are at a high risk of noncarcinogenic hazards from exposure to drinking water with high fluoride levels.[19] Previous studies indicate that exposure to fluoride in the early stages of life changes some protein expression in the hippocampus and cerebral cortex of rat offspring, which may contribute to impaired neurodevelopment following exposure.[20] Also, research showed a significant positive relationship between excess fluoride exposure from drinking water and prevalence of carotid artery atherosclerosis in adults living in fluoride endemic areas.[21]
Also, Wang *et al.* from China reported some findings, they indicated that in more than 90% of the cities, the fluorine concentration was less than 0.5mg/l.[4] Weathering and erosion of rocks, types of rocks, irrigation, fertilizers application, brick kilning by using coal and clay, groundwater evaporation and other anthropogenic and industrial activity are the major sources of elevated fluoride content in water.[10] Our findings showed that the average fluoride levels of water resources in the springs was higher in contrast to other seasons, which is inconsistent with Amouei *et al.* study.[14] Investigation of fluoride level in Sari have shown that the highest and lowest level of fluoride in drinking water of Mazandaran rural areas was observed in the spring and summer, respectively.[5] The results are in line with our study. In cold mountainous regions with reduced per capita consumption of water in winter, where only small amount of fluoride can be obtained from other sources, water fluoridation or using a fluoride mouthwash, can be good options to provide the required amount of fluorine for people especially children.[3, 9, 18]
Water fluoridation is the best and cheapest way to avoid fluoride deficiency symptoms.[15] Shaji *et al.* reported that the major factors responsible for the high fluoride level in the drinking water source of Alleppey could be from dissolution of fluorapatite as common mineral in the Tertiary sediments of this area. [22]
Evaluation of tap water in Tunisia showed that fluoride concentration was between 0 and 2.4 mg/L. Therefore, approximately 75% of the Tunisian population are at risk of dental decay, 25% have a potential risk of dental fluorosis, and 20% might have a risk of skeletal fluorosis according to WHO recommendation. Risk assessment of fluoride exposure was assessed depending on the age of the consumers.[23]

Conclusion

Fluoride concentration beyond WHO recommendations (0.5 to 1mg/L) in drinking water is a significant problem in many countries. Fluoride deficiency may cause increased tooth decay and bone disorder which lead to a decrease in bone mass, and high levels of fluoride exposure may adversely affect human health including dental fluorosis etc. To avoid these problems in both cases, at first, we must determine the fluoride concentration in drinking water as major source of fluoride. In Dehloran city, due to the fact that there is no clear evidence of fluoride concentration, we made a decision to determine it. Based on the low fluoride concentration in Dehloran water resources and given the role of fluoride in human health, the use of mouthwashes with fluoride or water fluoridation of water supply is highly recommended.

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