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Health risk assessment to fluoride in drinking water of rural residents living in the Poldasht city, Northwest of Iran

Mahmood Yousefi[a], Mahboobeh Ghoochani[a], Amir Hossein Mahvi[a,b,*]

[a] Department of Environmental Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran
[b] Center for Solid Waste Research, Institute for Environmental Research, Tehran University of Medical Sciences, Tehran, Iran

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ABSTRACT

This study analyzes the concentrations and health risks of fluoride in 112 drinking water samples collected from 28 villages of the Poldasht city, West Azerbaijan province in Iran. Results indicated that fluoride content in drinking water ranged from0.27 to 10.3 mg L^{-1} (average 1.70 mg L^{-1}). The 57% of samples analyzed exceeded the limit set for fluoride in drinking water. Based on findings from health risk assessment this study, the highest fluoride exposure for different regions of Poldasht city was observed in young consumers, children and teenager's groups. Also, most of the rural residents suffered from fluoride contaminated drinking water. The calculated HQ value was > 1 for all groups of residents in Agh otlogh and Sari soo areas. Therefore, it is imperative to take measures to reduce fluoride concentration in drinking water and control of fluorosis. Action should be implemented to enhance monitoring of fluoride levels to avoid the potential risk to the population.

1. Introduction

Access to safe drinking water is the natural right of all human beings and is one of the key development indicators. The presence of some chemical elements in drinking water at concentrations above the standard levels could lead to the health problems in the long-term. One of these chemicals is fluorine is an abundant element in the environment (Fawell et al., 2006; Aldrees and Al-Manea, 2010). According to US EPA fluoride is one of the twelve pollutants and it has been listed in the priority hazardous substances with US Agency for Toxic Substances and Disease Registry (Faraji et al., 2014; Aghaei et al., 2015; Mahvi et al., 2006). Fluoride enters the body in various ways, such as drinking water, breathing and food uptake. The most important source of human contact with fluoride is through drinking water (Dobaradaran et al., 2009). Many studies showed that the drinking water is the major source of daily fluoride exposure in Iran (Taghipour et al., 2016). Also in according to studies, about 90% of fluoride exists in drinking water is absorbed in the digestive system, while only 30–60% of fluoride exists in the food is absorbed in the digestive system (WHO, 1996). The standard level of fluoride in drinking water prevents in averages 40% of tooth decay. Since 1951 the United States Public Health Service Administration has been adding fluoride to the public source of drinking water in areas where fluoride concentrations are lower compared with standard levels (Guissouma et al., 2017). However, it has been shown that high concentration of fluoride has adverse health effects. Many adverse effects are including tooth decay at concentrations of less than 0.5 mg L^{-1} of fluoride in drinking water, fluorosis in long-term use of drinking water containing fluoride when concentration is in the range of 1.5–5 mg L^{-1} in drinking water, skeletal fluorosis when the concentration of fluoride in drinking water is 5–40 mg day^{-1}, drinking water containing 10 mg of fluoride from birth to adolescence causes genu recurvate and other health problem such as hypertension, infertility, neurological problems, Alzheimer's, thyroid, cancer, and arthritis has been reported in related with high concentrations of fluoride (Nouri et al., 2006; Fordyce et al., 2007; Boldaji et al., 2009; Rahmani et al., 2010; Amouei et al., 2012; Dobaradaran et al., 2011; Bazrafshan et al., 2012; Asghari et al., 2017). The Health Canada reported values 122 and 200 μg kg^{-1} bw day^{-1} of fluoride levels might cause to dental fluorosis and skeletal fluorosis. The 60 μg kg^{-1} bw day^{-1} of fluoride level set by US-EPA to prevent the dental fluorosis (Guissouma et al., 2017). Also, the World Health Organization (WHO) has recommended 0.5–1.5 mg L^{-1} to prevent the adverse effects of fluoride in drinking water. And also, the concentration of 0.5–1 mg L^{-1} fluoride in drinking water suggested to prevent tooth decay (WHO, 1996; Fordyce et al., 2007). Iran is a developing country with fluorite domains. In some regions, fluoride concentrations are higher than the standard levels. The Poldasht city is one of these areas where located in the northwest of Iran. A study was conducted in Bohlol abad village showed fluoride content in drinking water was above the standard level (Karimzade et al., 2014). Therefore, we determined the fluoride content of drinking

* Corresponding author at: Department of Environmental Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran.
E-mail address: ahmahvi@yahoo.com (A. Hossein Mahvi).

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Table 1
The population of villages of Poldasht.

Village name	Population	Village name	Population
Pomak	539	Ghargholog olia	171
Moradlo vasati	275	Zakerlo	630
Ghoulish lanamish	1111	Shidi	946
Gharghlogh sofla	348	Hasan kandi	771
Nazok sofla	286	Orooj mohammad	463
Nazok olyia	420	Bohlol abad	1363
Ghir kendi	282	Ghoch kandi	1115
Divankhane	480	Tape pashi	387
Shiblo olia	278	Chakhmaghlo sofla	348
Shahrak aras	1944	Eshgh abad	323
Ghare jalo	499	Dailan kandi	1207
Eshg abad	323	Agh otlogh	462
Moradlo olia	183	Bohlol kandi	848
Sarisoo	779	Shotloo	719

water in 28 villages of the Poldasht from March 2014 to March 2016. And also, we assessed the potential risks from fluoride ingestion through drinking water for infants, children, teenagers and adults. The findings of this study could be useful for future planning of water resources as well as public knowledge about health problems related with fluoride high concentrations.

2. Material and methods

2.1. Study areas

Poldasht city is located in North West Azerbaijan province of Iran and North Western with coordinates (UTM) X = 446,625–513,055 to the east and Y = 4,344,280–4,402,863 is located north latitude. Poldasht meteorological station showed that in a long-term, the average rainfall was equal to 131.5 mm. The city has also borderline from West and North with Turkey. According to the national statistics of Iran, the urban population of Poldasht is 8584 and 66 villages of Poldasht have 27,778 rural population. It also has an area of 72,870 square kilometers. The population of subjected villages was shown in the Table 1(Fig. 1)

2.2. Determination of fluoride in drinking water

The samples of this study were taken from drinking water resources including wells and springs from 28 villages of the city. A total of 112 samples were collected every six month over two consecutive years from March 2014 to March 2016. The water samples were collected in the sterile plastic containers and then transported to the laboratory. Fluoride concentration of water samples was determined using SPADNS method according to instruction of Standard. Analytical method for fluoride determination in the range of 0.0625–1.75 mg L^{-1} (r = 0.9993) and the higher concentrations of this range were diluted and measured. The fluoride concentration was assessed by Spectrophotometer (DR/5000, USA) and obtained limits of determination (LOD) and quantification (LOQ) were 0.12 ppm and 0.37 ppm respectively.

2.3. Risk assessment of fluoride

A human health risk assessment is the process to estimate the nature and probability of adverse health effects in humans who may be exposed to chemicals in contaminated environmental media, now or in the future. So, the quantitative health risk assessment of fluoride through consumption of drinking water was evaluated in rural population of Poldasht city, West Azerbaijan Province. For this purpose, tap water samples were taken from different villages. We divided population into four age groups based on physiological and behavioral differences as same as Ghoochani et al. study (Ghoochani et al., 2017) as fallow: infants (less than 2 years), children (2 to < 6 years), teenagers (6 to < 16 years) and adults (≥ 16 years). Exposure to fluoride was calculated in these groups using Eq. (1):

$$EDI = \frac{C_f \times C_d}{B_w} \quad (1)$$

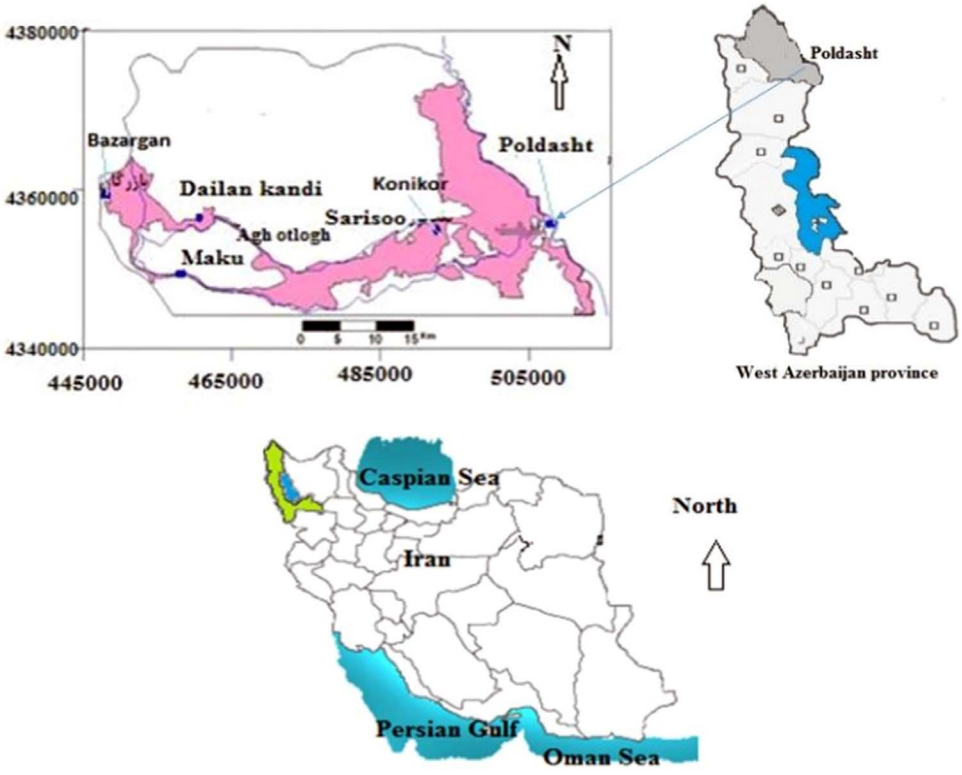

Fig. 1. Location of the study areas in Poldasht City, West Azerbaijan, Iran.