Data article

The concentration data of fluoride and health risk assessment in drinking water in the Ardakan city of Yazd province, Iran

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A R T I C L E  I N F O

Article history:
Received 12 December 2017
Received in revised form
13 February 2018
Accepted 26 February 2018
Available online 6 March 2018

Keywords:
Fluoride
Groundwater
Health risk
Ardakan
Iran

A B S T R A C T

According to the World Health Organization (WHO) reports, Iran is located in the global fluoride belts, so that is why carrying out extended research on this contaminant anion in water supplies must be considered. Due to the various industries in the Ardakan city, this region is severely suffering from fluoride contamination. This study was designed to investigate the fluoride concentration and its distribution pattern as well as related health risk assessment in groundwater resources of 28 villages of the Ardakan city in Yazd province using SPADNS method according to standard instructions. Our results show that, the average concentration of fluoride was 2.92 mg/l (range: 0.9–6 mg/l), also in half of the villages, the concentration range of this element was over than standard level (1.5 mg/l) given by WHO rules. In addition, risk assessment results showed that HQ value is higher than 1 in 46.4% of samples of groundwater resources in age groups of infants,

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https://doi.org/10.1016/j.dib.2018.02.069
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children, teenagers and adults. Therefore, it is necessary to take measures to reduce fluoride concentration in drinking water in order to control resultant fluorosis. Actions should be implemented to enhance monitoring of fluoride levels to avoid the potential risk of high Fluoride concentration.

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Specifications table

| Subject area         | Water quality                         |
|----------------------|---------------------------------------|
| More specific subject area | Water fluoride                        |
| Type of data         | Tables, Figures                       |
| How data was acquired | Analysis of all water samples were done according to the Standard Methods for Examination of Water and Wastewater. Anions and cations including magnesium, calcium, and chloride as well as temporary and permanent hardness were measured using titration method. Turbidity meter (model Hach 50161/co 150 model P2100Hach, USA) was used to analysis of electrical conductivity. Also, determining of fluoride, nitrate, and sulfate concentration in comparison with internal standards were done using Hach DR5000 spectrophotometer. |
| Data format          | Raw, Analyzed                         |
| Experimental factors | All water samples were stored in polyethylene bottles in a dark place at room temperature until analysis. |
| Experimental features| Determine the concentration levels of fluoride |
| Data source location | Ardakan region, Yazd province. Iran   |
| Data accessibility   | Data are included in this article      |

Value of the data

- Based on health risk assessment, and data analysis we found that HQ amounts exceeded standard levels, and therefore defluoridation of drinking water could be recommended in subjected region.
- In order to minimize of fluoride in point of use (POU) and point of entry (POE), urgent actions needed to be implement to address them is necessary.
- The Iranian standard of fluoride in drinking water is based on the maximum annual temperature of the area because of temperature impact on water evaporation.

1. Data

Concentration of studied physicochemical parameters in the groundwater of the 28 villages and towns of the Ardakan region are summarized in Table 1 and Fig. 1. Also geological distribution of
**Table 1**

Physico-chemical and statistically analyzed water quality parameters.

| Village          | F⁻  | Ca²⁺ | Mg²⁺ | Na⁺ | K⁺  | NO₃⁻ | NO₂⁻ | SO₄²⁻ | Cl⁻   | EC   | Fe    | Mn    |
|------------------|-----|------|------|-----|-----|------|------|-------|-------|------|-------|-------|
|                  | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (μmhos/cm) | (mg/L) | (mg/L) |
| Ashtijeh 1       | 5.5 | 276  | 7.29 | 153.044 | 15 | 80   | 0.02 | 190   | 400   | 5370 | 0.02  | 0.01  |
| Ashtijeh 2       | 5   | 132  | 43.74 | 221.158 | 10 | 32   | 0.02 | 190   | 475   | 4600 | 0.03  | 0.002 |
| Khavas kuoh      | 1.6 | 66.8 | 39.609 | 169.008 | 12 | 52   | 0.01 | 185   | 230   | 1552 | 0.01  | 0.003 |
| Malek kuoh       | 4   | 110  | 27.945 | 202.469 | 8.4 | 22   | 0.02 | 180   | 350   | 2300 | 0.01  | 0.003 |
| Fakhr abad       | 5   | 156  | 63.18 | 167.319 | 12 | 80   | 0.02 | 175   | 425   | 4500 | 0.02  | 0.002 |
| Sarsofa          | 4.8 | 132  | 102.1 | 145.276 | 15 | 40   | 0.02 | 190   | 500   | 4000 | 0.02  | 0.003 |
| Chah shahi       | 4.4 | 120.8 | 51.104 | 257.853 | 11 | 27.2 | 0.01 | 195   | 475   | 2820 | 0.02  | 0.005 |
| Zerjou           | 1.2 | 91.2 | 17.496 | 152.571 | 4.9 | 28.4 | 0.02 | 190   | 220   | 1540 | 0.03  | 0.003 |
| Oghda(Qanat)     | 5.6 | 114.8 | 49.329 | 198.164 | 5.3 | 31.6 | 0.02 | 200   | 400   | 3150 | 0.03  | 0.002 |
| Shams abad       | 5.1 | 200  | 87.48 | 499.014 | 10 | 36   | 0.01 | 175   | 475   | 4530 | 0.02  | 0.003 |
| Sefid kuoh       | 5.6 | 304  | 46.17 | 106.226 | 13 | 39.2 | 0.05 | 430   | 375   | 4810 | 0.05  | 0.003 |
| Haftadar         | 5   | 180  | 72.9  | 337.246 | 5  | 34.8 | 0.06 | 280   | 300   | 4080 | 0.09  | 0.003 |
| zerjou(Qanat)    | 6   | 160  | 58.32 | 216.036 | 15 | 16   | 0.03 | 620   | 220   | 4700 | 0.05  | 0.005 |
| Oghda 2          | 1   | 40   | 14.58 | 216.237 | 5  | 17.2 | 0.03 | 175   | 225   | 1500 | 0.02  | 0.001 |
| Saghand          | 1.3 | 112  | 42.525 | 512.097 | 14 | 18   | 0.02 | 740   | 195   | 5000 | 0.06  | 0.007 |
| Rotab posht bam  | 4.6 | 49.2 | 19.926 | 150.588 | 3.1 | 20.4 | 0.03 | 148   | 155   | 1230 | 0.02  | 0.003 |
| Maghستان        | 1.3 | 50   | 25.515 | 421.049 | 2.4 | 20   | 0.02 | 70    | 76    | 650  | 0.03  | 0.002 |
| Diuok            | 1.1 | 76   | 38.88 | 218.974 | 5.8 | 28.8 | 0.03 | 195   | 250   | 2900 | 0.02  | 0.001 |
| Robat            | 4.75| 68   | 85.05 | 556.875 | 4.9 | 13.6 | 0.02 | 190   | 200   | 2600 | 0.06  | 0.004 |
| Maghستان2       | 1.3 | 116  | 38.88 | 145.939 | 5.2 | 10   | 0.01 | 190   | 300   | 2680 | 0.02  | 0.003 |
| Tuot             | 1.5 | 36   | 17.496 | 101.451 | 3.5 | 18.5 | 0.06 | 90    | 100   | 520  | 0.01  | 0.002 |
| Kharanegh        | 0.9 | 72   | 75.33 | 963.195 | 3.1 | 17.1 | 0.02 | 195   | 150   | 4800 | 0.01  | 0.001 |
| Tork abad 1      | 1   | 60   | 87.48 | 945.936 | 4  | 10.5 | 0.04 | 200   | 210   | 4000 | 0.03  | 0.007 |
| Tork abad 2      | 0.9 | 52   | 89.91 | 142.56 | 3.6 | 12   | 0.01 | 185   | 300   | 2890 | 0.04  | 0.001 |
| Tork abad 3      | 1.3 | 46   | 8.019 | 249.579 | 3  | 30   | 0.03 | 170   | 250   | 2500 | 0.03  | 0.001 |
| Haji abad        | 1.2 | 29.6 | 5.346 | 512.962 | 3.6 | 12.5 | 0.01 | 70    | 45    | 500  | 0.05  | 0.005 |
| Hamane           | 0.2 | 52   | 21.87 | 273.723 | 5.1 | 20.1 | 0.01 | 200   | 350   | 2410 | 0.02  | 0.002 |
| Haji abad zarin  | 1   | 92   | 41.31 | 192.324 | 3.5 | 22   | 0.02 | 210   | 340   | 2450 | 0.01  | 0.003 |
| Mean             | 2.9 | 106.9 | 44.96 | 164.87 | 7.37 | 28.2 | 0.02 | 222.4 | 285   | 3020.79 | 0.03  | 0.003 |
| Max              | 6   | 304  | 102.1 | 512.1 | 15  | 80   | 0.06 | 740   | 500   | 5370 | 0.09  | 0.01  |
| Min              | 0.2 | 29.6 | 5    | 34    | 2.4  | 10   | 0.01 | 70    | 45    | 500  | 0.01  | 0.001 |
| S.D              | 2   | 68.87 | 28.33 | 96.62 | 4.35 | 17.8 | 0.01 | 144.8 | 126   | 1473.12 | 0.02  | 0.001 |

**Fig. 1.** Groundwater water sampling sites in Ardakan.
Fig. 2. Geological distribution of fluoride in study area.

Fig. 3. Comparison of fluoride concentration with 1053IR standard.

Table 2
Pearson’s correlation coefficient.

|       | F⁻   | Ca²⁺  | Mg²⁺  | Na⁺   | K     | NO₃⁻  | NO₂⁻  | SO₄²⁻ | Cl⁻   | EC    | Fe    | Mn    |
|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| F⁻    | 1    |       |       |       |       |       |       |       |       |       |       |       |
| Ca²⁺  | 0.711** | 1    |       |       |       |       |       |       |       |       |       |       |
| Mg²⁺  | 0.266 | 0.181 | 1    |       |       |       |       |       |       |       |       |       |
| Na⁺   | -0.157 | -0.062 | -0.27 | 1    |       |       |       |       |       |       |       |       |
| K     | 0.585** | 0.695 | 0.173 | 0.351 | 1    |       |       |       |       |       |       |       |
| NO₃⁻  | 0.478 | 0.6    | -0.038 | -0.017 | 0.577** | 1    |       |       |       |       |       |       |
| NO₂⁻  | 0.153 | 0.175 | 0.006 | -0.221 | -0.114 | -0.024 | 1    |       |       |       |       |       |
| SO₄²⁻ | 0.206 | 0.387 | 0.168 | 0.59   | 0.559 | -0.066 | 0.152 | 1    |       |       |       |       |
| Cl⁻   | 0.554 | 0.6    | 0.316 | 0.172 | 0.548 | 0.507** | -0.225 | 0.043 | 1    |       |       |       |
| EC    | 0.498 | 0.724** | 0.521** | 0.205 | 0.628 | 0.399 | 0.055 | 0.565 | 0.563 | 1    |       |       |
| Fe    | 0.252 | 0.225 | 0.239 | -0.069 | 0.057 | -0.158 | 0.341 | 0.481 | -0.162 | 0.239 | 1    |       |
| Mn    | 0.309 | 0.476 | 0.037 | 0.222 | 0.536 | 0.277 | 0.028 | 0.432 | 0.163 | 0.468 | 0.149 | 1    |

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
fluoride in the study area is also illustrated in Figs. 2 and 3 and also Fig. 3 comparison of fluoride concentration with 1053IR standard. In addition, the correlation between the all parameters is shown in Table 2.

Fluoride exposure levels for different rural population was observed in four age groups as Fig. 4. Also, the HQ value for young groups was higher than 1 in Fig. 5.

2. Experimental design, materials and methods

2.1. Study area description

This study was conducted during September and December 2015 in Ardakan city of Yazd province (Fig. 1). Based on the Demographic Information of Iran, this city is populated with almost 77,758 with an area of 23,806 square kilometers that is located in 64 km North West of Yazd province. Ardakan city has a dry climate with an average temperature of 32.5 °C, an average annual rainfall of 58 mm and 2270 mm evaporation annually. Existence of mentioned industries plays a significant role in water contamination of this region via fluoride.
2.2. Determination of the water fluoride concentration

The samples were collected from drinking groundwater resources including wells and aqueducts from 28 villages of the city. A total of 112 samples were collected every four seasons over year from September-December 2015.

All water samples were analyzed according to the Standard Methods for Examination of Water and Wastewater. Also using titration method, temporary and permanent hardness, magnesium, calcium, and chloride were measured. Electrical conductivity was also analyzed with turbidity meter (model Hach 50161/co 150 model P2100Hach, USA). On the other hand, using Hach DR5000 spectrophotometer nitrate, and sulfate were determined compared with internal standards. Sampling was conducted with one-liter polyethylene bottles which were immersed in nitric acid for 24 h then washed with 10 percent HCL and finally washed with distilled water. It has to be mentioned that before the collection of the samples, sampling containers had been rinsed at least three times with water. Fluoride concentration of collected samples was determined using SPADNS method according to Standard instruction [1–10]. Then we assessed the fluoride concentration using Spectrophotometer (DR/5000, USA). Pearson’s correlation coefficient was used for comparisons of association between all physicochemical parameters and data analysis was done using Excel 2016 software.

3. Risk assessment of fluoride

In order to understand the probability of adverse health effects it is beneficial to assess the health related risk of chemicals in contaminated water. Risk assessment is often the first step in safeguarding safety and health. In present study we used empirical models proposed by USEPA (1989) to estimate the non-carcinogenic effects of subjected contaminants [11–16]. So, we quantitatively assessed the health related risk of fluoride through drinking water consumption in villages of Ardakan city, Yazd Province. Tap water samples were collected from different villages to meet the requirements of our study. In accord with same study (Mahmood Yousefi et al.) we divided population into four age groups based on physiological and behavioral differences including: infants (less than 2 years), children (2 to < 6 years), teenagers (6 to < 16 years) and adults (≥ 16 years). Also using following equation, the daily exposure dose of fluoride through water ingestion was measured [15]:

\[
\text{EDI} = \frac{C_f \times C_d}{B_w} \tag{1}
\]

Estimated Daily Intake (EDI) of fluoride is calculated based on the daily average consumption of drinking water (Cd), concentration of fluoride in drinking water (Cf) and body weight (Bw). EDI is expressed in unit of milligrams per kilogram of body weight per day. The data of water consumption and body weight were gathered via a questionnaire that was asked of the target groups (infants, children, teenager and adults). The average water consumption rates in infants (0–2 years old), children (2–6 years old), teenagers (6–16 years old) and adults (≥ 16 years old) were 0.08, 0.85, 2 and 2.5 L day⁻¹, respectively. Body weight of target groups was considered 10, 15, 50 and 78 kg, respectively.

Hazard Quotient (HQ) means the ratio of a single substance exposure level (dose or concentration) over a specified period of time to the RfD or RfC derived for the same period of time for the same substance. A ratio larger than unity suggests that the concentration of the chemical is high enough to cause chronic non-carcinogenic effects.

Hazard quotient (HQ), an estimate of non-carcinogenic risks from exposure to fluoride through different exposure route, was calculated using following equation. Hazard quotient (HQ) is calculated by dividing the estimated daily intake (EDI) by the safe dose (RfD) [Eq. (2)]; in present study, we represent the fluoride intake risk from drinking water by HQ [16–18]:

\[
\text{HQ} = \frac{\text{EDI}}{\text{RfD}} \tag{2}
\]

The reference dose (RfD), is an estimate of a daily exposure to the human population over a lifetime without a considerable risk of deleterious effects. According to the Integrated Risk Information System,
USEPA (USEPA, IRIS U), the oral reference doses of fluoride is 0.06 mg kg\(^{-1}\) d\(^{-1}\) [15,16]. As it is mentioned previously, the HQ is the ratio between the EDI and RfD and HQ value less than one indicates that even for sensitive populations it is unlikely to experience adverse health effects. Whereas, when the value of HQ is exceeded 1, it well be understood that the adverse health effects are possible and the non-carcinogenic risk exceeds the acceptable level.

**Acknowledgements**

The authors want to thank authorities of Tehran University of Medical Sciences for their comprehensive support for this study.

**Transparency document. Supporting information**

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.dib.2018.02.069.

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