

Original Article

## Analysis of Ground Water Fluoride Content and its Association with Prevalence of Fluorosis in Zarand/Kerman: (Using GIS)

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### Abstract

**Statement of Problem:** The concentration of fluoride in water is usually higher in areas around the coal mines. Zarand region in the south-east of Iran is known for its coal mines. Some studies have shown the high prevalence of fluorosis and some studies reported high levels of fluoride in the region.

**Objectives:** This study aimed to use Geographic Information System (GIS) to assess the relationship between water fluoride content and the prevalence of fluorosis and its spatial distribution in Zarand region.

**Materials and Methods:** This cross-sectional study aimed to recruit 550 people aged 7-40 years in Zarand. Dental examination for fluorosis was conducted based on the Dean's Index. The level of fluoride in the water was determined in samples of water taken from 35 areas. Information on fluorosis and fluoride content was mapped on GIS.

**Results:** Most participants lived in rural areas (87.25%) and had an educational status of high school level (66%). About 23% of the examined people had normal teeth, 10% had severe and 67% had mild to moderate fluorosis. Distribution of severe fluorosis was higher in areas with higher levels of fluoride in the water according to GIS map.

**Conclusions:** GIS map clearly showed a positive relationship between the prevalence and severity of fluorosis with the level of fluoride in water in Zarand. The GIS analysis may be useful in the analysis of other oral conditions.

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## Introduction

Fluoride is considered to be among the top ten chemicals which are a concern for public health [1]. Based on exposure levels, it can provide both protective and harmful effects on the teeth. Exposure to optimum levels of fluoride has an anti-cariogenic and anti-bacterial effect whereas long-term exposure to higher levels of fluoride, during age periods in which the teeth crowns are formed, is associated with dental fluorosis [2-5]. Adults are not at risk of dental fluorosis, although bone fluorosis and poisoning may occur rarely in extreme fluoride intake in all ages [1, 6].

Ground water is the main source of drinking water and, therefore, is the main source of fluoride ingestion [7]. A concentration of more than 1.5 ppm increases the risk of fluorosis [8,9]. Several factors contribute to environmental and natural factors associated with high fluoride levels in the ground waters. Coal industries are among the ways in which humans add fluoride into the environment [5]. Coal mine districts in Kerman (the largest province in the southeast of Iran) are areas with major concern. Among them are Zarand city and its surrounding villages [4]. Until now it has not received enough attention for this problem. Therefore, the aim of this study was to assess the fluoride content and fluorosis prevalence in Zarand in details using geographical soft wares.

A geographic information system (GIS) is a computer system designed to present spatial or geographic data on maps. It is used for better visualization and interpretation of data. In this system, maps related to different datasets are combined, overlaid and presented as one final diagram. This diagram illustrates the alteration of different variables on a geographic map and enables the lay people to understand and interpret the relationships easier. This would give a new, more precise and attractive view of the problem which could motivate the policy makers to present a final solution for the problem. Therefore, geographic information system (GIS) was used to assess the relationship between the water fluoride content and prevalence of fluorosis and its spatial distribution on GIS.

## Materials and Methods

This cross-sectional study was conducted on 7- to 40-year-old people (the population with permanent dentition) living in Zarand, in the south east of Iran.

This study was approved by Kerman University of Medical Science research committee. Based on previously reported prevalence of fluoride in the region and considering a power of 90%, a sample size of 550 people was recruited for the study using a multi-stage random sampling method (city district/village, street, family, and person). Before data collection, a written and informed consent was obtained from the participants or their parents.

Demographic data (age, gender, and education level), place of living before 12 years of age (rural or urban areas), duration of residency and their past and present drinking water source were recorded. A trained and calibrated dentist carried out all dental examinations using disposable mirrors and probes and a head light. The participants' fluorosis status was recorded using the Dean's Index (Table 1)[10].

All participants should have been residents in the region for the first six years of their life (the time period in which dental fluorosis may affect the permanent teeth). People with severe systemic disease, those who had lost more than six of their anterior teeth or covered them with crowns/veneers, and those under orthodontic treatment were excluded from the study. All 35 main ground water sources of Zarand were chosen in a consensus method for water sampling. One liter plastic containers were acid washed and sterilized before sampling. Each container was flushed with the sample water three times and then filled in. After final filling, the samples were sent to Kerman geology research lab on the same day. Ion chromatography was used to assess the fluoride concentration of water samples. Detailed data related to water sampling and each regions' fluoride content were presented in a previously published paper [7]. Data on prevalence of fluorosis and severity of cases, and also on fluoride content of water were adjusted and recorded using GIS Arc and Map 10 software.

## Results

In the present study, 549 eligible subjects were examined. Among them, 231 (42%) were men and 318 (58%) women. The majority of the participants (22.4%) were in the 25-35 age groups. Most participants (87.25%) lived in rural areas and had an education level of high school level (66%).

Figure 1 shows the alteration of Fluoride content in different regions of Zarand on a GIS map. Motaharabad had the highest fluoride level with 3.51 ppm and Sang village had the lowest level of fluoride (0.33

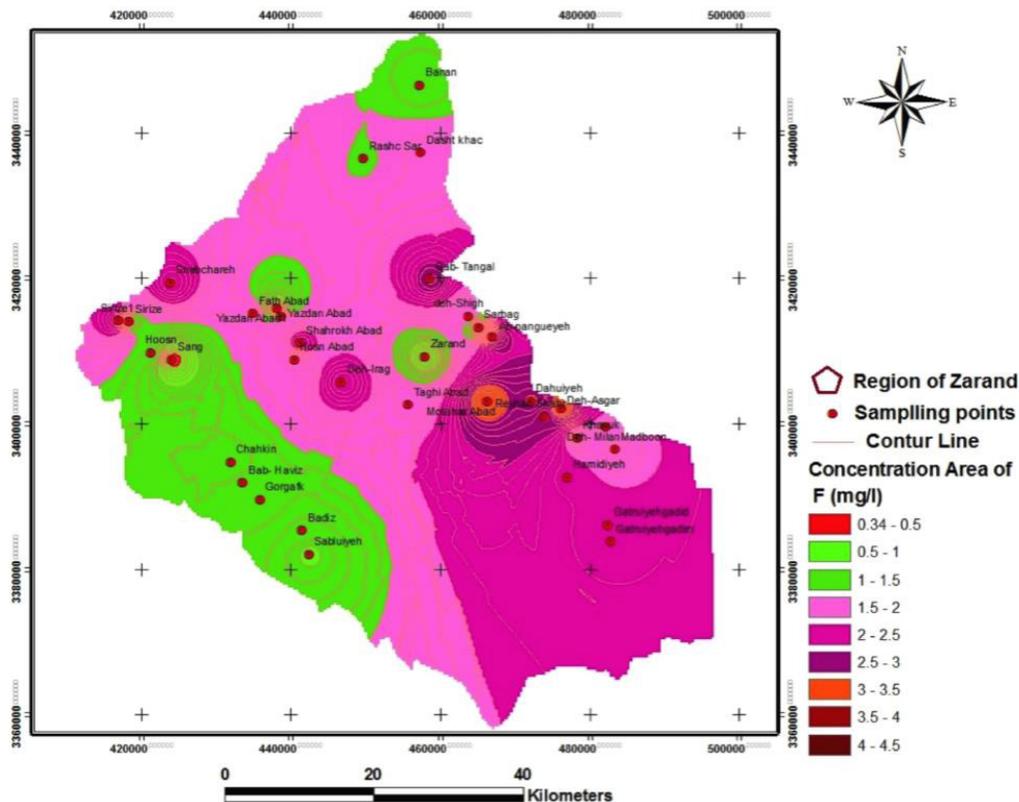
**Table 1: Dean’s Index for study of dental fluorosi**

Classification	Code	Criteria – description of enamel
Normal Fluorosis	0	The enamel represents the usual translucent semivitriform (glass-like) type of structure. The surface is smooth, glossy and usually of pale creamy white color
Questionable Fluorosis	1	The enamel discloses slight aberrations from the translucency of normal enamel, ranging from a few white flecks to occasional white spots. This classification is utilised in those instances where a definite diagnosis is not warranted and a classification of ‘normal’ not justified
Very Mild Fluorosis	2	Small, opaque, paper white areas scattered irregularly over the tooth but not involving as much as approximately 25% of the tooth surface. Frequently included in this classification are teeth showing no more than about 1 – 2mm of white opacity at the tip of the summit of the cusps, of the bicuspid or second molars.
Mild Fluorosis	3	The white opaque areas in the enamel of the teeth are more extensive but do involve as much as 50% of the tooth.
Moderate Fluorosis	4	All enamel surfaces of the teeth are affected and surfaces subject to attrition show wear. Brown stain is frequently a disfiguring feature
Severe Fluorosis	5	All enamel surfaces are affected and hypoplasia is so marked that the general form of the tooth may be affected. The major diagnostic sign of this classification is discrete or confluent pitting. Brown stains are widespread and teeth often present a corroded-like appearance.

ppm). As illustrated in Figure 1, the regions located in the west, southwest and to a little extent north-east of Zarand had a water fluoride content of lower optimum level whereas central areas through east

and southeast had a water fluoride content which was higher than the optimum level.

Regarding dental fluorosis, about 23% of people had normal teeth, 10% had severe and 67% had mild



**Figure 1: The alteration of Fluoride content in different regions of Zarand on a GIS map**

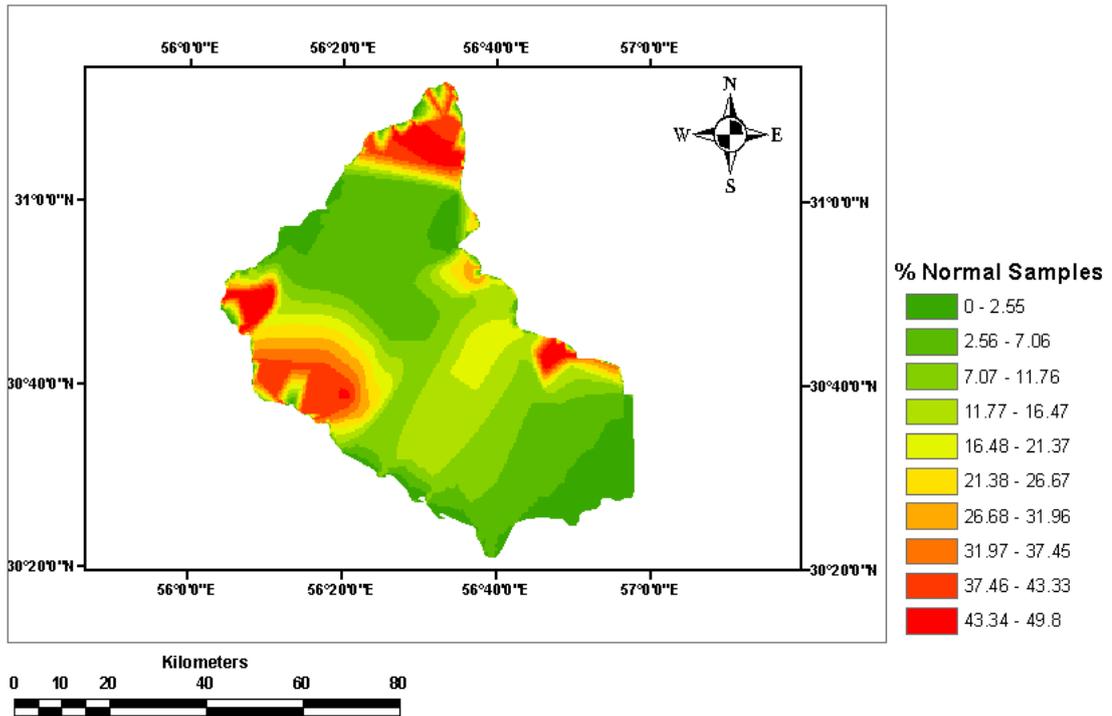


Figure2: Prevalence of "no fluorosis" in different regions of Zarand

to moderate fluorosis. The highest prevalence of severe fluorosis (45%) was seen in two villages of Gorgak and Ab-pangueyeh. Figures 2 to 6 illustrate the prevalence of fluorosis according to its severity in different regions of Zarand. Figure 7 shows the integrated prevalence of fluorosis and fluoride

concentration of water in Zarand regions on one map. It is clear that those residing in the east and south-east areas with high fluoride in the ground water had a higher prevalence of severe fluorosis. Also, it is not a problem in western areas which have fluoride lower than the optimum level.

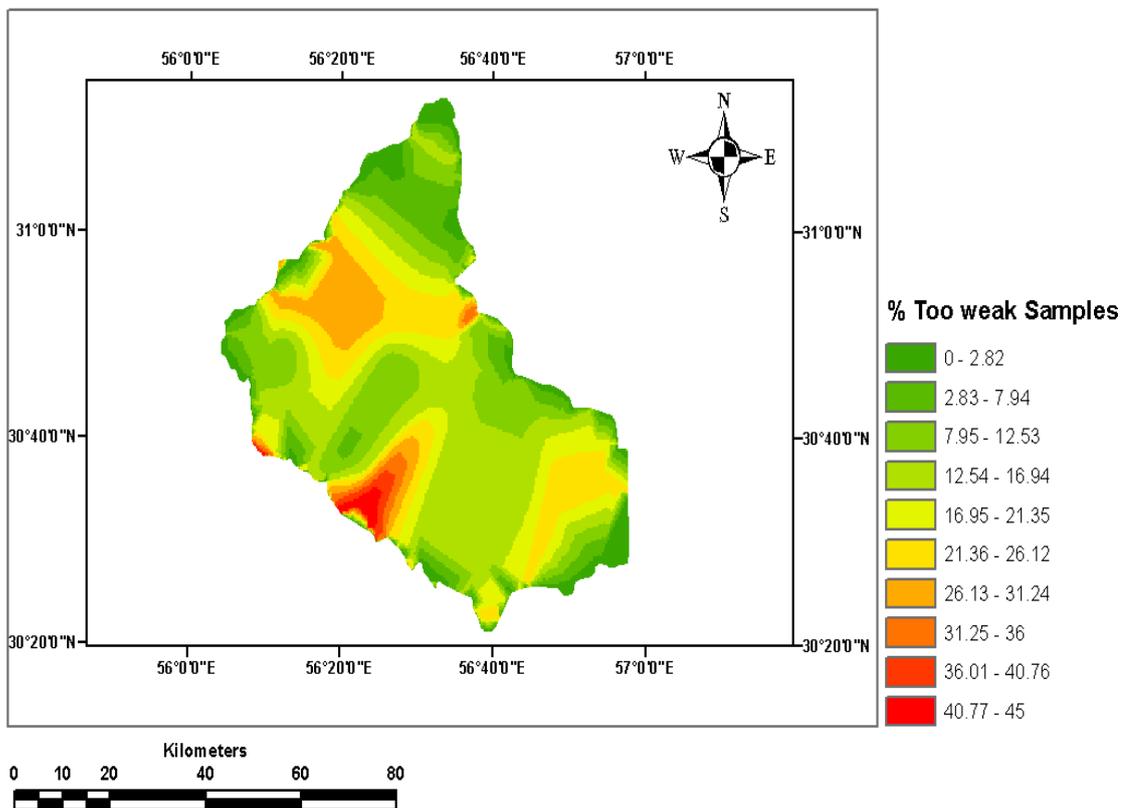


Figure3: Prevalence of "very mild fluorosis" in different regions of Zarand

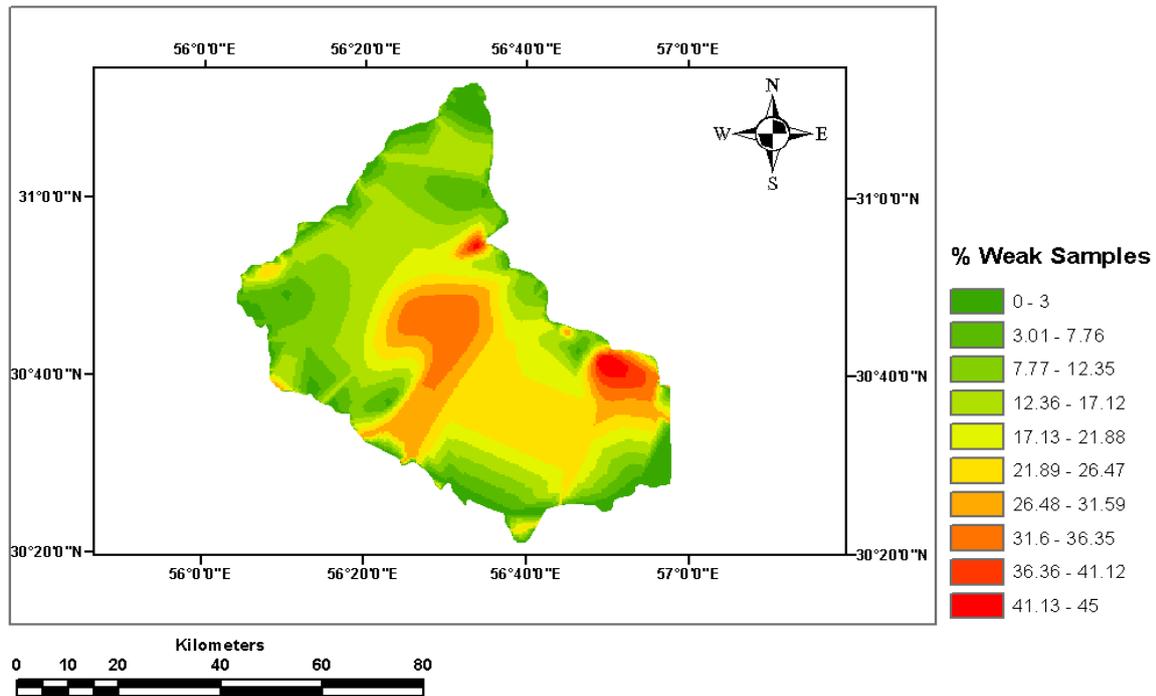


Figure 4: Prevalence of "mild fluorosis" in different regions of Zarand

### Discussion

The aim of the study was to illustrate the fluorosis status and fluoride content of water on GIS maps and to integrate maps in order to give a clearer picture of the relationship between them. According to the GIS map, it is clear that regions with higher fluoride concentration in their ground water had higher levels

of fluorosis. Zarand City had a fluoride concentration of 0.53ppm which was under the optimum level. Among the surrounding villages, Motahar-abad, Deh-asgar, Ab-panguyeh and Dehuyeh had the highest levels of ground water fluoride, respectively. It was also prevalent in these areas especially in Ab-panguyeh with a 44.4% prevalence of severe dental fluorosis. This is possibly due to the environmental

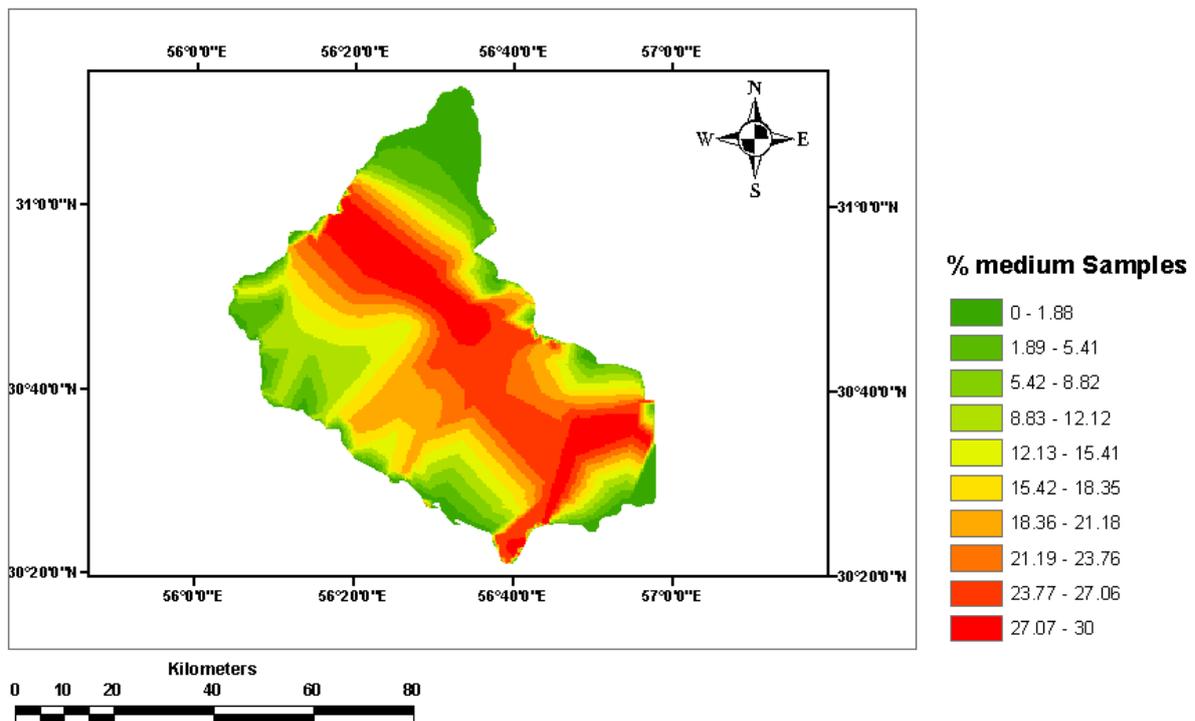


Figure5: Prevalence of "moderate fluorosis" in different regions of Zarand.

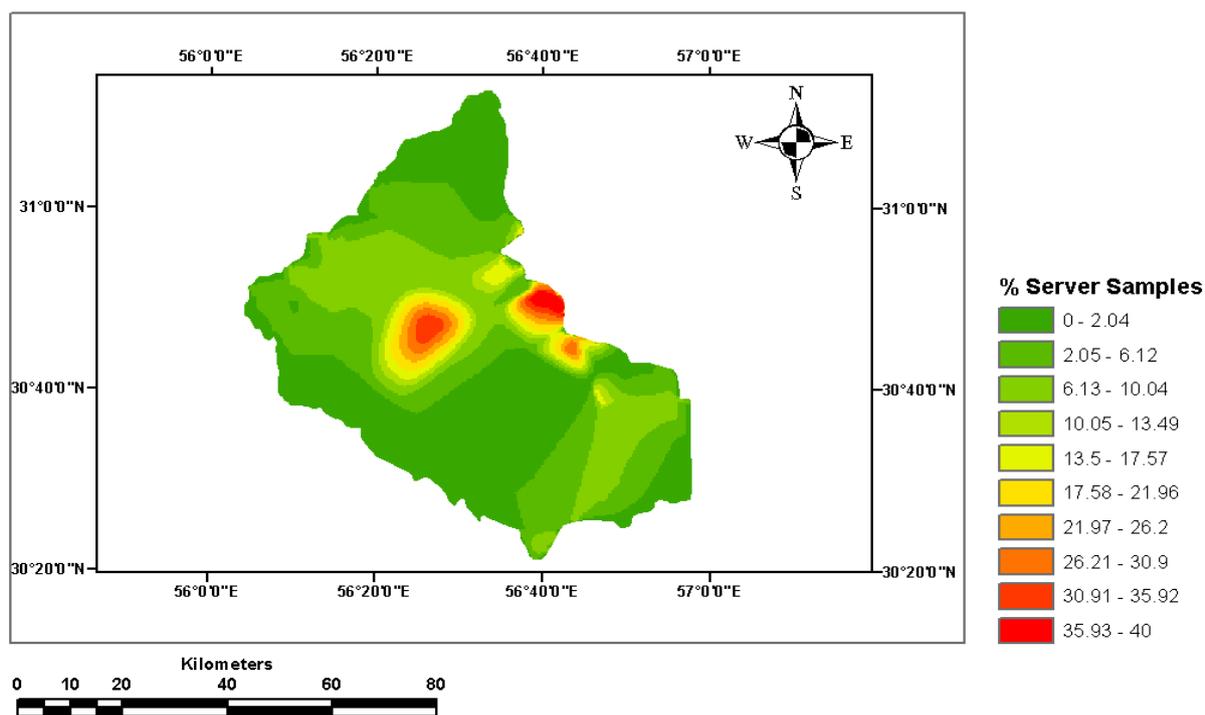


Figure 6: Prevalence of "severe fluorosis" in different regions of Zarand

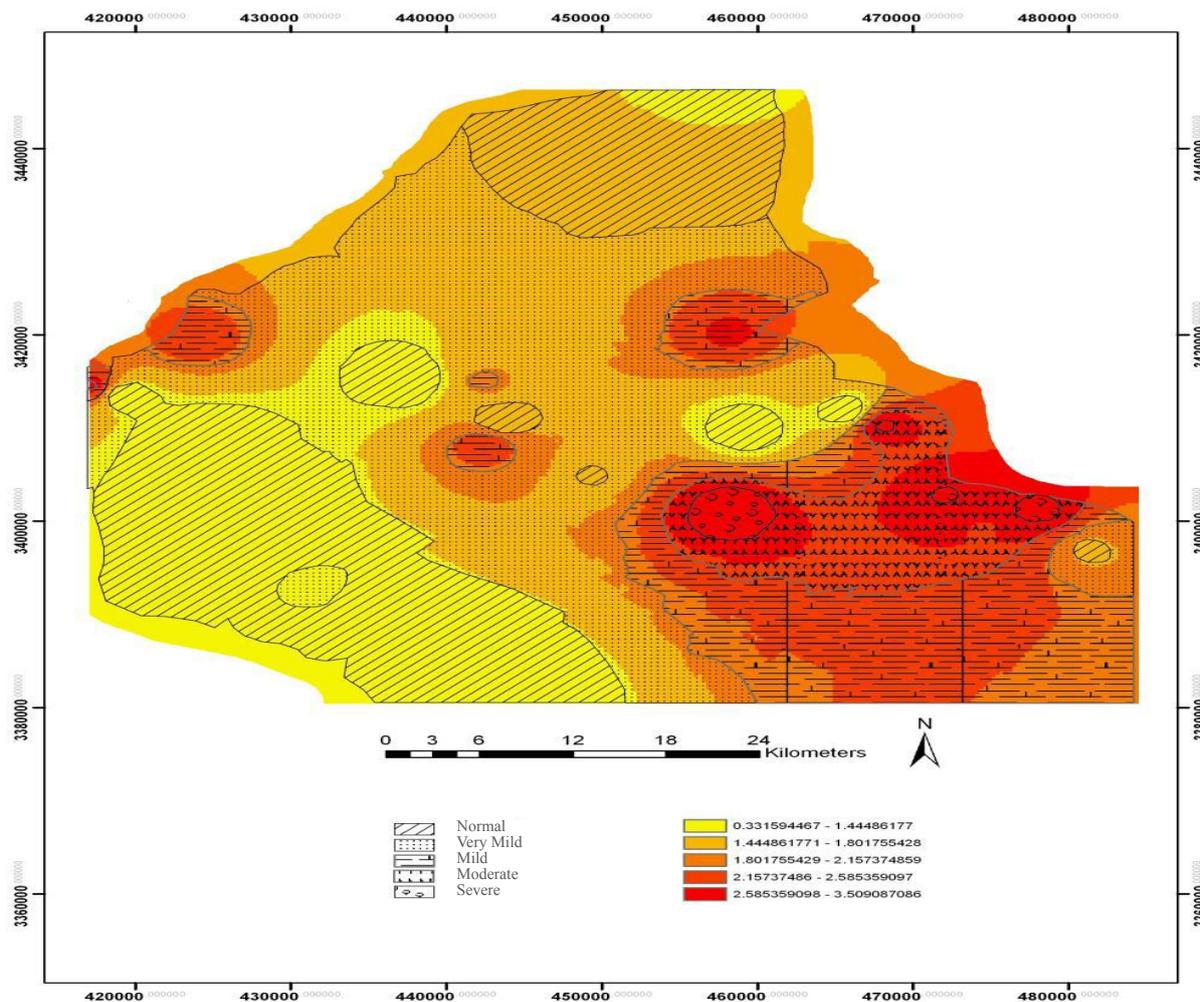


Figure 7: Lowest Prevalence of fluorosis, Low P of F, Medium P of F, High P of F, Highest P of F

and geologic characteristics of the region. Presence of Scheelite structures containing layers of coal and Alluvial deposits due to weathering is the main cause of fluoride increase in the ground water of these regions.

Other studies have also found a positive relationship between fluoride concentrations and severity [11-16]. In another study, the main cities of Kerman were assessed regarding their water fluoride content. Although Zarand city had the highest fluoride content (0.92 ppm) and Rafsanjan had the lowest fluoride concentration (0.13 ppm) in their drinking water, the fluorosis status was not significantly different between these two cities. In this study, Zarand city was investigated (not the villages and towns around Zarand, as in our study) and its fluoride content was still under the optimum level. This is why fluorosis status was not prominent [4].

Fluorine is the lightest halogen element which can be found as the fluoride ion in nature [17]. It is prevalent in rocks where it can replace the hydroxide ion. In Zarand, weathering of sandstones, Claystones and Siltstones with inlayers of coal, dolomite, lime and Scheelite results in the replacement of hydroxide by fluoride. Fluoride dissolves in the surrounding water passing through the rocks and, therefore, it enters the ground water. When the water PH is acidic, fluorine is absorbed into kaolinite clay minerals, but in Zarand due to alkaline PH, the water is left enriched with fluorine elements.

Studies have shown that GIS is a powerful tool for investigating different characteristics of the ground water [18]. GIS map shows that the ground water fluoride level is higher than optimum in a large area of Zarand region which poses a health risk to people residing there. Although drinking water fluoride is the main source of the ingested fluoride in one's diet, other foods which are high in fluoride and have a prominent role in fluoride uptake [19,20] should also be carefully consumed, especially in young children. Black tea is among the popular drinks in the diet of Iranians and contributes to a high daily intake of fluoride [21]. However this study had some difficulties because of the wide geographic area and hard access to people for examination, but it could be a good start to propose oral diseases on GIS maps for all the country.

## Conclusions

GIS was a very good tool to determine relationship

between severities of fluorosis with fluoride content of the drinking water in Zarand region. In the east and southeast of Zarand region, the level of fluoride was higher than optimum. Higher prevalence of fluoride in these areas indicates the need for continuous monitoring of the ground water before being it is piped into residential areas. Also, west and southwest regions had ground water fluoride levels lower than optimum; this could be a risk factor for dental caries. Therefore, regular dental visits and the use of professionally applied fluoride or education regarding the use of fluoride mouthwashes is essential for residents of these areas.

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**Conflict of Interest:** None declared.

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