



## Fluoride levels in Soil and Crops of Tomato and Onion Farms of Zanjan

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### ARTICLE INFO

#### Article history:

Received October 13, 2016

Accepted December 1, 2016

#### Article Type:

Original Article

#### Keywords:

Fluoride  
Tomatoes  
Onions  
Soil  
Zanjan

### ABSTRACT

**Background:** Fluoride is an essential nutrient for the human body. The major routes of fluoride intake include food and drinking water, though the absorption of fluoride from food is much easier. The aim of this study was to evaluate the amount of fluoride in the soil and tomato and onion crops on farms of Zanjan.

**Methods:** Three farms of each crop (tomato and onion) were selected randomly. Each farm was divided into 10 sections, and one sample of soil and crop of each section was taken which means 120 samples in total. Fluoride concentrations in the soil and crops were measured using the Ion Selective Electrode (ISE) and repeated 3 times.

**Results:** The mean concentration of fluoride in soil samples from studied farms in Zanjan was  $0.83 \pm 0.17$  mg/kg. The mean concentrations of fluoride in tomatoes and onions of Zanjan were observed  $2.10 \pm 0.80$  and  $2.23 \pm 0.64$  mg/kg, respectively.

**Conclusion:** There was no significant difference between fluoride concentration in tomatoes and onions, although there was a significant difference between the amount of fluoride in the soils of studied farms ( $P_v < 0.024$ ). No significant correlation was observed between the fluoride levels of soils and the fluoride levels of tomatoes ( $R^2 = 0.126$ ) and onions ( $R^2 = 0.008$ ).

## 1. Introduction

Fluoride is one of the most beneficial micronutrients for the human body. Much of fluoride in the body is stored in skeletal tissue.

Although its role in tooth and bone health has been proven [1, 2], in excess, it can harm the body

in many ways [3].

Based on the amount and the duration of exposure to fluoride, its complications can vary from mild dental fluorosis to crippling skeletal fluorosis [1].

**To cite:** Moeinian Kh, Mehrasbi MR, Hassanzadazar H, Kamali K, Rabiei E. Fluoride levels in Soil and Crops of Tomato and Onion Farms of Zanjan. *J Hum Environ Health Promot.* 2016; 2(1):47- 51.

In a cohort study conducted in China between 1998 and 2008, a steady and strong relationship between high doses of fluoride and reduced IQ was observed [3]. Also, an epidemiological study in the United States showed that an increase in the amount of fluoride in drinking water causes changes in both male and female sex hormone levels and thus reduces fertility [4]. Fluoride ion prevents glycolysis by inhibiting some enzymes causing an increase in blood sugar levels. Also, since diabetic patients consume more water than healthy people, fluoride accumulation and excretion through the kidneys leads to renal dysfunction [5-7]. Absorption of 1-3 mg fluoride per day helps to prevent tooth decay [8]. Fluoride intake in children was 0.05 mg/kg in areas with 1 ppm fluoride concentration in drinking water.

Whereas in general, the optimal fluoride intake in adults is 0.07 mg per kg of body weight per day [9,10]. Normally, adequate daily intake of fluoride for Infants up to 6 months; children aged 6 months to 2 years old; 8 years old; and adult male and female 0.01 mg/kg body weight, 0.05-0.1, 3 and 4 mg/kg/day, respectively.

The United States Department of Agriculture (USDA) reported that about 75% of fluoride intake to body was through diet, water, and juices [11].

Cengeloglu et al., stated that fluoride pollution of the earth is created in two ways: natural and anthropogenic [12]. As WHO reports, minerals and large discharges into subsoil water sources of fluorine contained in rocks are natural sources of fluoride pollution [8]. Anthropogenic fluoride contamination is created by human activities like motorization, fluoridation of drinking water supplies (Low and Bloom), industrialization and utilization of fluoride- containing fertilizers and pesticides [13].

According to WHO, recommended amount of fluoride in drinking water is 1-1.5 mg [1].

Averagely, most foods have 0.2-0.3 ppm of fluoride, except tea that has 10-75 ppm and seafood that have about 5-15 ppm of fluoride [14].

In most regions of Iran, the amount of fluoride in drinking water is below standard, level, the complications of the lack of fluoride is far more important than the complications of its excessiveness, and it is necessary to naturally compensate this lack of fluoride by ingestion of foods containing fluoride.

Food plays an important role in supplying the body's fluoride. Average consumptions of two commonly used crops, tomatoes and onions per capita in Iran were approximately 71.6 kg and 8-12 kg per year, respectively, especially in Zanjan province. Therefore, the aim of this study was to evaluate the fluoride content of tomatoes and onions and investigate the relationship between fluoride content of each crop with fluoride concentration in the soil of harvested farms in Zanjan city as the largest city of Zanjan province of Iran [15, 16].

## 2. Materials and Methods

This cross-sectional study was conducted on crops of 6 farms (3 Unigen tomato and 3 Yellow onion farms) that were selected randomly based on the location of the planting and harvesting of products in Zanjan city during the summer 2015 .

Each farm was divided into 10 sections and one sample of soil and crop was taken from each section which means 120 samples of soil, tomatoes and onions in total. All samples were dried under environmental conditions and then were ground and sieved. Fluoride concentrations in the soil and crop were measured using Fluoride Ion Selective Electrode (ISE) (PASCO scientific Model CI- 6728, USA).

At first, fluoride stock solution was prepared using sodium fluoride (NaF) (Merck, Darmstadt, Germany) with a concentration of 22.1 mg per liter, then a standard curve was provided using 0, 0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5 mg per liter concentrations of standard solutions.

Sample preparation of the crops was conducted by grinding two grams of tomato and onion samples and boiling with 20 cc distilled water.

Samples were covered with aluminum foil and maintained at room temperature for 2 hours.

Then, brewed samples were transferred to test tubes and centrifuged for 30 minutes at 3,000 rpm.

5 cc of sample extracts was mixed with 5 cc of total ionic strength adjustment buffer (TISAB) to maintain the ionic strength of the solution and eliminate the influence of interfering ions. In the end, fluoride content was read using ion selective electrodes (PASCO scientific Model CI-6728, USA).

For soil samples preparation, at first all soil samples were transferred to the laboratory, dried, crushed and passed through two-millimeter sieve.

Then 16 grams of soil sample was mixed with 50 ml of calcium chloride 0.01 mol/l and was placed in a shaking incubator for 16 hours at 25° C. Samples were filtered and mixed with an equal amount of the TISAB solution. In the end, fluoride content was read using ion selective electrodes (PASCO scientific Model CI-6728, USA) [17].

Fluoride concentration of the samples was determined using the read values with a drawn calibration line.

Statistical analysis of the results was performed using SPSS ver. 22 software and Mann-Whitney and Kruskal-Wallis tests with a 95 % confidence interval.

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### 3. Results and Discussion

According to table 1, the average amounts of fluoride are  $0.83 \pm 0.17$  ppm in the soil,  $2.10 \pm 0.80$  ppm in the Unigen tomatoes and  $2.23 \pm 0.64$  ppm in yellow onions.

The average and maximum concentrations of fluoride in the soil of northwestern region of Zanzan were  $0.83 \pm 0.17$  mg/kg and 1.23 mg/kg, respectively.

Mirghaffari and Shariatmadari evaluated the mean concentration of soluble fluoride in the soil samples around major industrial centers in Isfahan using ISE method which was 1.0 mg/kg. Maximum reported amount was 3.2 mg/kg that showed higher levels of fluoride compared to our study findings [17].

Istvan Pais and Benton Jones (1997) in their book have reported the fluoride concentrations in soil between 10 to 20 mg/kg [18]. Arnesen and coworkers have reported the concentration of fluoride in soil extracts taken from different depths and distances around aluminum plants in Norway between 5 - 35 mg/kg [19].

Utilization of Phosphate fertilizers is one of the main causes of fluoride contamination of soil since they contain under 1 to over 1.5% Fluorine. Phosphate fertilizers play an essential role in maintaining farm productivity. However, as they are made from phosphate rocks that formed millions of years ago, they contain a range of minerals other than phosphorus one of which minerals is fluoride [20].

The difference in fluoride concentration in farm soils in Zanzan ( $P_v < 0.024$ ) was significant, which probably could be related to soil characteristics such as pH, mineral composition and utilization range of phosphate fertilizers by farmers [16, 17, 18]. Moreover, the mean concentrations of soluble fluoride in Unigen tomato and yellow onion samples in Zanzan were  $2.10 \pm 0.80$  mg/kg and  $2.23 \pm 0.64$  mg/kg, respectively .

In Mirghaffari and Shariatmadari's study, the usual amount of fluoride in plants has been reported to be 0.2 - 20 mg/kg [17].

The United States Department of Agriculture (USDA) has reported the mean fluoride content of most foods including fresh raw tomato and onion 0.02 ppm and 0.01 ppm, respectively [11].

McClurre has reported the average fluoride concentrations of 0.24 mg/ kg in dry tomatoes and 2.4 mg/kg in dry onions that show proximity to obtained results [14].

In a study conducted in villages of India, on measurement of fluoride in some crops using ion selective electrodes, mean concentrations of fluoride in onions in two villages were  $5.67 \pm 0.10$  mg/kg and  $10.50 \pm 0.09$  mg/kg respectively. Also,

the mean fluoride concentration in tomatoes was reported  $13.48 \pm 0.08$  micrometers [21] indicating the results that are much higher than our present study results.

**Table 1:** Average Fluoride contents in the soil, Unigen tomatoes and Yellow Onions of Zanjan city.

Sample	Numbers	Mean (ppm)	Standard Deviaton (ppm)	Maximum (ppm)	Minimum (ppm)
Soil	60	0.83	0.17	1.23	0.42
Unigen Tomatoes	30	2.10	0.80	4.88	1.17
Yellow onion	30	2.23	0.64	3.74	1.08

Statistical analysis showed a significant difference between fluoride concentration in the tomato samples of three farms ( $P_v < 0.001$ ), while there was not statistically significant difference in onions of different farms ( $P_v < 0.01$ ); thus it seems that the type of product can have an impact on fluoride uptake from the soil.

Despite significant differences between the soil fluoride of studied farms ( $P_v < 0.024$ ), a strong correlation was not observed between the concentration of fluoride of soils on farms and the fluoride of tomatoes ( $R^2 = 0.126$ ) and onions ( $R^2 = 0.008$ ). Overall, the evidence suggests that the fluoride of soil has a slight (if any) impact on the fluoride content of crops [14].

There were some limitations on this study design including the bias that may have occurred in collection of soil sample regarding the depth and size of samples collected, thus based on preliminary findings of this study, to assess more accurately, sampling must be done at different distances and in greater numbers. Since numerous studies suggest that fluoride uptake by leafy vegetables is naturally higher than non-leafy ones, the crop selection as samples may result in selection bias. In the present study we investigated fluoride content of irrigation water that can cause the bias of finding the probable cause of fluoride content increase.

#### 4. Conclusion

Regarding the above mentioned limitations, it could be concluded that most of the investigated soil and samples have fluoride levels under critical limits. However, continuous monitoring of fluoride should be taken into consideration in other agricultural crops particularly leafy vegetables.

Precautions must be taken in the utilization of the crops as continuous ingestion may result in considerable increase in the daily dietary intake leading to deleterious bioaccumulation in the human body. Finally it is recommended that farmers be educated to use agricultural fertilizers properly, especially phosphate fertilizers.

#### Acknowledgement

We would like to express our gratitude to Vice-Chancellery of Research and Technology of Zanjan University of Medical Sciences for their financial support.

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