FLUORIDE AND SILICON CONTENT IN DRINKING WATER

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SUMMARY: Though the fluoride content of drinking water has been implicated as the main cause of fluorosis, the severity and incidence of the disease do not always correlate with the fluoride content of drinking water. It has been suggested that other components in the water and/or in the diet may enhance or protect from fluoride toxicity. Silicon has been suggested to enhance the fluoride toxicity. In this study 227 water samples from fluorotic and non-fluorotic areas in India are analysed for silicon and fluoride contents. Water samples containing less than 2 mg F/L show significant positive correlation between the fluoride and the silicon content. Water samples containing more than 2 mg F/L sow a significant negative correlation between the fluoride and silicon content. A significant positive correlation between silicon and fluoride was observed in four none fluorotic areas, while there was no correlation in samples from fluorotic areas. It is discussed that the silicon content of water and food may play an important role in fluorosis. The difference in the mean fluoride content of water from bore well and water from open wells was not found statistically significant.

Key words: Fluoride; Silicon; Drinking water; Fluorosis; Fluorotic areas, India.

INTRODUCTION

Endemic fluorosis has been a major public health problem in India as well as in many other countries. Although the fluoride content of drinking water is considered to be the most important factor responsible for endemic fluorosis, results of many studies have shown that the incidence and severity of the disease does not always run parallel with the levels of fluoride in drinking water.[1,2,3] Therefore, it was suggested that some other factors present in water and/or diets would enhance the fluoride toxicity.

Reddy and Srikantia[4] observed that high protein, adequate vitamin C and calcium could prevent the appearance of symptoms of fluorosis in experimental animals. Lakshmaiah and Srikantia[5] have observed that the fluoride retention was significantly higher on sorghum based diet than those based on rice. Even general under-nutrition has been shown to enhance the deleterious effects of fluoride ingestion in cattle.[6]

Recently Kaminisky and co-workers[7] observed that radiographically detectable steosclerosis due to chronic exposure to high fluoride (8 mg/L) in drinking water, was not associated with clinical symptoms. This has further strengthened the idea that there are other factors in water and/or diet that would enhance or decrease fluoride toxicity. Studies carried out at the National Institute of Nutrition, Hyderabad, have shown that the silicon content of the diet is one such factor.[8] In those studies, it was observed that there was a significant increase in fluoride content of femur of animals fed high silicate diet. Silicon has been shown to be an essential element for chicks and rats[9,10] and it is also known to be essential for bone mineralization.

Since it is a common observation that elements supplied through drinking water are absorbed to a large extent, we were interested to know the silicon content of drinking water samples from fluorotic areas. To the author's knowledge, there is only one Russian report[11] linking silicon content of drinking water samples to hardness of

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water. Keeping in view of these studies, a detailed investigation is planned with the following objectives:

- To find out whether there exists any relationship between fluoride and silicon content of drinking water samples collected from different areas.
- Whether the fluoride content of deep bore wells is different from the surface water or water from dug wells.
- Whether silicon content of drinking water follows any particular trend with varying fluoride content in fluorotic and non-fluorotic areas.

TABLE 1. Number of water samples and their locations.

Sample Location	No. of samples	Samples from bore wells
Kakatiya Nagar	11	7
Prashant Nagar	34	14
Seethaphalmandi	41	15
Nacharam	29	10
North Eastern parts of India	38	0
Samples from villages in Nalgonda (fluorotic area):		
I. Samastha Narayanpuram	13	12
II. Shivannagudem, Ananthampet	36	36
III. Yeragandlapalli	12	12
IV. Indurthi	13	13

MATERIALS AND METHODS

Two hundred and twenty seven drinking water samples were collected. Of these 74 samples were from endemic fluorotic villages in Nalgonda district of Andhra Pradesh State, 38 from North-eastern part of India and the remaining 115 samples were from surrounding areas of Hyderabad city, table 1.

In all water samples, the fluoride content was measured using Orion fluoride ion specific electrode and silicon by a plasma atomic emission spectrometer with 251.611 nm emission line.[12] The recoveries of added elements, fluoride and silicon, were nearly 100 % and replicates agreed very well. Analysis of standard reference materials showed a good agreement with the reported values.

As there were distinctly two patterns in the distribution of fluoride values in relation to silicon values, the water samples were divided into 2 groups. The first group of 146 water samples with less than 2 mg F/L and the second group of 81 water samples with 2.0 mg F/L or more. By regression equations it was evaluated whether the silicon content could be expressed as a function of the fluoride content in these 2 groups was evaluated. The statistical fitness was evaluated using the student's 't' test and the correlation coefficients were calculated between fluoride and silicon contents.[14]

RESULTS

Bore well vs. surface water. The distribution of the drinking water samples is given in table 1. About 52 % of the samples were from bore wells. There was no statistically significant difference in the mean fluoride content of water samples from bore well and open wells.

Silicon and fluoride contents of water F < 2 mg/L. The relationship between the contents of silicon and fluoride for the first group of samples is given in Figure 1. There is a significant positive correlation between the two parameters (P<0.001) (r=+0.7297). Since 1 mg/L fluoride content is suggested as upper limit for drinking water in tropical countries the corresponding silicon content appears to be 28 mg/L. According to the observed trend every increase in 0.5 mg F/L, the increase in silicon content is about 10 mg/L.

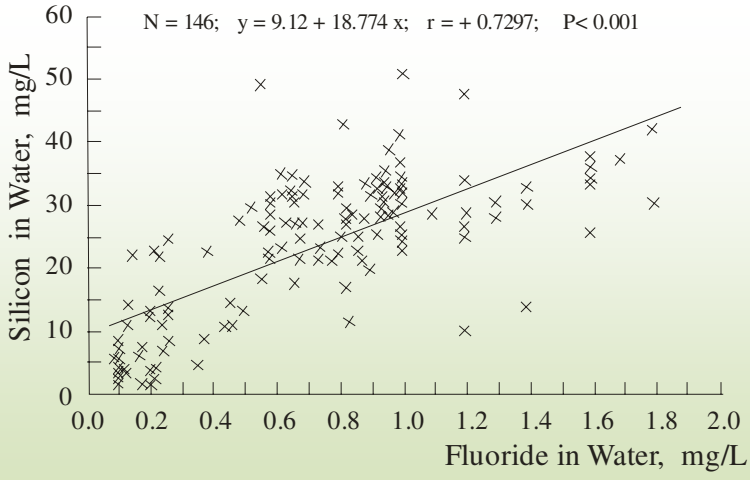

FIGURE 1. Silicon versus fluoride content of drinking water samples with F< 2 mg/L.

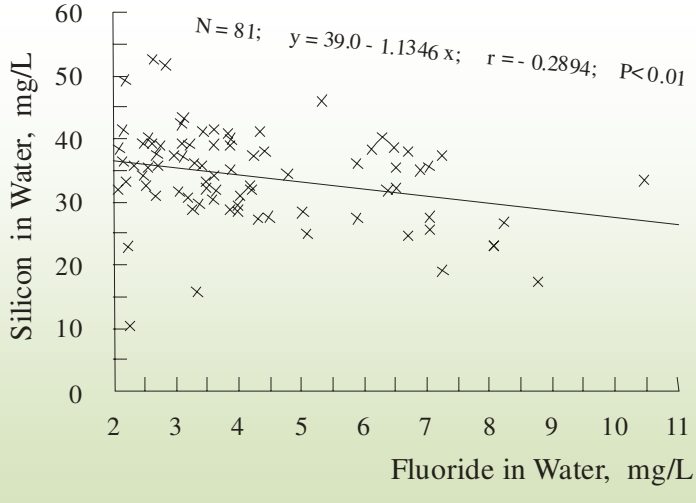

FIGURE 2. Relationship between fluoride and silicon content of drinking water samples

Silicon and fluoride contents in water with F ≥ 2 mg/L. Figure 2 shows the obtained relationship of silicon to fluoride content in water samples with more than or equal to 2 mg F/L. There is a significant negative correlation (r = -0.2894, p<0.01)

between fluoride and silicon content. The decline in silicon content in relation to fluoride content appeared to be 1.2:1.

Region-wise analysis. The results were also analysed from another angle. The water samples were from 6 distinctly different areas. The relationship between fluoride and silicon content is calculated for all 6 locations. It was observed that wherever the fluoride content was high, i.e. fluorotic area, there was no relationship between fluoride and silicon content. Further, wherever fluoride values were low, i.e. non-fluorotic area, there was a significant positive correlation.

DISCUSSION

The results presented in this study are different from those of Teotia and Teotia[13] who suggested that the fluoride content of deep bore wells was lower than those from the dug wells. Recently Kaminisky and co-workers,[7] have reported that there were no clinical symptoms of fluorosis in population groups who consumed for several years drinking water with 8 mg F/L. It is reported that the fluoride content of femur of animals fed high silicate diet was significantly high.[8] It is a common observation that in India the symptoms of fluorosis are seen in areas where the fluoride content of drinking water is 3 to 4 mg/L. It is possible that even the low fluoride values may become toxic when their silicon content is high. However, in situations where the fluoride content is high, e, g. 6 to 8 mg/L, the low silicon content may act as protective factor and prevent the manifestation of the disease. Reddy and Srikantia[4] observed that high Ca, vitamin C and protein protected the experimental animals from fluorosis.

There appears to be some limit for the silicon solubility in water samples (maximum about 50 mg/L). At higher concentration silicon compounds polymerise and become insoluble.

There are no reports in India on the silicon content of water samples. In one report from Russia the silicon content was about 25 mg/L with hardness less than 2.5 meq/L.[11] Since it is suggested that high silicon content may enhance the fluoride toxicity, it appears that 28 mg Si/L in waters containing 1 mg F/L is optimal. The silicon content of water and food samples might play an important role in fluorosis in some areas in India where the fluoride content of drinking water is moderately high.

The region-wise analysis of the data showed that silicon and fluoride content of water samples from north eastern parts of India are very low.

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