SUMMARY: This study reports fluoride (F) accumulation in vegetables and a cultivated crop together with dietary F intake among a selected group of adults in Junitpur, a F-endemic area of the Birbhum district, West Bengal. Variable F accumulation occurs in a cultivated crop (mustard) and vegetables (spinach, coriander, marcellia, potato, tomato, brinjal, onion, and beans). The F content of leafy vegetables was found to be higher [transfer factor (TF)>1] than that of fruiting and tuber vegetables as well as seed crops. Analysis of the diet of eight adults in four families (4 males and 4 females, age 30–40 and 25–35, respectively), revealed that drinking water contributed 43%, rice meal 26%, and vegetables 30% to the total mean F intake.

Keywords: Birbhum district, West Bengal; Dietary fluoride intake; Fluoride in crops and vegetables; Fluoride translocation; Junitpur, West Bengal.

INTRODUCTION

Serious health problems associated with chronic fluorosis occur in many parts of the world1-5 and endemic fluorosis has been identified in 20 states of India.6-7 About 62 million people, including 6 million children are at risk in India from dental, skeletal, and/or nonskeletal endemic fluorosis.8 From a management point of view for prevention and control of fluorosis, changing the water source and reducing the F concentration of drinking water are the main strategies that can effectively diminish the incidence of fluorosis. However, the prevalence of fluorosis cannot be completely eliminated merely by altering the source of drinking water and reducing its F concentration.9-11 It is the total amount of F absorbed in a human body that needs to be considered: the sum of F intake from water, food, and air. Consequently, even though F absorption from food is generally less than from water, it is not valid to assume the daily F intake of a person will not exceed a certain standard by controlling only one of the F sources.12-13 Currently, reducing the F concentration of drinking water is essentially the only method employed to meet the requirements set in 1983 by the ISI (Indian Standard Institute).14 But the extent high F water damages human health via the food chain is uncertain. Determining dietary F intake is therefore useful and important for estimating the retention of F in man. Pathways and patterns of F excretion associated with different intakes of F have been described by various researchers.15-18

Junitpur village (24º06’07.5”N and 87º46’54.7”E) of Rampurhat block of the Birbhum district, West Bengal, where fluorosis has been known to be prevalent for some 6–8 years, was selected as one of the study areas for conducting the present research. The total population of Junitpur is about 400. The F level in the drinking water ranges from 0.39 to 6.80 mg/L with a mean of 2.06 mg/L.19 The F concentration in the irrigation water varies from 0.6 to 4.06 mg/L. In the soil, both

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Fluoride in crops and dietary intake in a fluoride-endemic area of West Bengal

Gupta, Banerjee

FH2O and F CaCl2 extractable range between 1.45 and 3.80 mg/kg (mean 2.63) and between 0.85 and 6.75 mg/kg (mean 3.8), respectively. Junitpur was selected as an appropriate area for conducting this research because people of this village are not only consuming F-contaminated drinking water but also the crops/vegetables cultivated in their own agricultural fields as food items. F accumulation in paddy (rice) irrigated by F-contaminated water was reported from this study area. Apart from that study, no study of F accumulation in other crops and vegetables cultivated in the study area have been reported. The present research was conducted to estimate: i) F accumulation in harvested crops and vegetables grown in the study area, and ii) dietary intake of F among selected people living in the study area.

MATERIALS AND METHODS

Estimation of fluoride in crops and vegetables: The collected vegetables were washed with distilled water. Their roots, stalks, leaves, and flowers, were then separated and further dried, chopped into pieces, and blended thoroughly. Next, 100-g samples of each part were air-dried at 80°C, ground, and passed through a 40-mesh sieve. The un-sieved material was sealed in polythene plastic bottles for further use. For the husked rice and mustard, 100-g samples were ground and passed a 40-mesh sieve. As above, the un-sieved material was sealed and saved in polythene plastic bottles. Water-soluble F (FH2O) and total F (F Total) were determined in these samples as described in the literature.

Transfer factor (TF): As reported by Gupta and Banerjee, similar to heavy metal translocation from soil to plant parts, translocation of F between soil and plant is an important criterion for the selection of crop plants for the cultivation on soils contaminated with elevated level of FH2O. A ratio >1 means higher accumulation/concentration in the plant parts than is present in the soil.

Estimation of dietary intake: Four families, whose food source was their own cultivated crops and vegetables (Table 1) irrigated by F-contaminated water, were included for study. Out of a total of sixteen family members, only the eight adults consisting of four males and four female in the age group of 30–40 years and 25–30 years, respectively, were selected for the estimation of F intake through their diet.

RESULTS AND DISCUSSION

Fluoride accumulation in crops and vegetables: Water-soluble fluoride (FH2O) and F Total along with the transfer factor (TF) values in crops and vegetables are presented in Table 1. A definite pattern of F distribution in plant parts was found for different species. The F translocation in edible parts was much lower (TF<1) for the grain-yielding crop plant (mustard), fruiting vegetables (tomato, brinjal), and tubers (potato), with an exception of beans (TF>1), while higher F

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TF = \frac{\text{Concentration of H}_2\text{O}-\text{extractable F in plant body at contaminated site}}{\text{Concentration of H}_2\text{O}-\text{extractable F in soil at that site}}
\]
translocation was observed for leafy vegetables (spinach, coriander leaves, and marcellia). Earlier investigations found increased F enrichment in plant parts where metabolism is higher.\textsuperscript{23} The higher F enrichment/translocation in leafy vegetables can be attributed to the increased rate of metabolism (and/or photosynthesis rate) in leafy shoots in comparison to seeds/grains or other storage organs (tubers). Higher metabolic activity can be associated with higher intake of water resulting in increased F concentrations in leafy shoots/vegetables.

### Dietary intake of fluoride

The amount of F in the environment is obviously closely associated with human health. Here it was found that each of the selected adult family members required an average of 500 g of meal ingredient, 500 g of vegetable food, and 5 L of water per day. These people are members of a farming community, and both the men and women work hard the whole day on their agricultural land. They therefore consume more water than conventional intake. Moreover, the study area has a tropical climate, which contributes to high intake of F from water as well as food. The proportion of F from other pathways, such as tea and meat, to the total daily intake of F is very small, so these sources can be neglected in the calculation of the total daily F intake. The meal ingredient is mainly rice with a total F content of 12.31 mg/kg.\textsuperscript{20} The average F concentration in eight vegetables (spinach leaf, coriander leaf, marcellia, potato, tomato, brinjal, onion, and bean) is 7.15 mg/kg, and the average level of F in the drinking water, as noted earlier, is 2.06 mg/L.\textsuperscript{19}

The calculated results for the above entities are shown in Table 2. The total intake of F through meal, vegetables, and drinking water is estimated to be 23.61 mg/day (Table 3). F intake through meal, vegetables, and drinking water account for 26%, 30% and 44% of the total F amount, respectively. Therefore, F in drinking water was not the main source of F intake, but a major portion of F came from meal and vegetables. The sum of the total percentage from the latter is 56% (26% + 30%), which is greater than the 44% intake from the water.

### Table 1. Water-soluble and total F content in seeds of crops and edible part of vegetables\textsuperscript{a} (n=4\textsuperscript{b}) in Junitpur

<table>
<thead>
<tr>
<th>Crop/vegetable</th>
<th>F\textsubscript{Total} (mg/kg)</th>
<th>F\textsubscript{H2O} (mg/kg)</th>
<th>TF\textsuperscript{c}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mustard</td>
<td>4.40±0.21</td>
<td>0.87±0.06</td>
<td>0.30</td>
</tr>
<tr>
<td>Spinach leaf</td>
<td>11.37±0.32</td>
<td>4.70±0.17</td>
<td>1.62</td>
</tr>
<tr>
<td>Coriander leaf</td>
<td>26.94±0.16</td>
<td>11.97±0.26</td>
<td>4.13</td>
</tr>
<tr>
<td>Marcellia</td>
<td>24.37±1.12</td>
<td>3.33±0.16</td>
<td>1.15</td>
</tr>
<tr>
<td>Potato</td>
<td>4.01±0.19</td>
<td>0.58±0.02</td>
<td>0.20</td>
</tr>
<tr>
<td>Tomato</td>
<td>8.75±0.12</td>
<td>0.28±0.01</td>
<td>0.10</td>
</tr>
<tr>
<td>Brinjal</td>
<td>14.46±1.03</td>
<td>1.29±0.09</td>
<td>0.44</td>
</tr>
<tr>
<td>Onion</td>
<td>9.19±.19</td>
<td>2.59±0.06</td>
<td>0.89</td>
</tr>
<tr>
<td>Bean</td>
<td>15.26±0.32</td>
<td>3.07±0.15</td>
<td>1.06</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Data are mean±SD. \textsuperscript{b}n=4 meaning each sample was analysed in parallel 4 times. The average value and standard deviation were calculated in terms of the dry mass of plants. \textsuperscript{c}Translocation of F between soil to plant.
CONCLUSIONS

As seen here, the F content of leafy parts of vegetables grown in this area is much higher than that of fruits and tubers. F accumulation in seeds is low compared to other parts of the plant. In order to reduce the risk of human exposure to F, the use of F-contaminated irrigation water, especially for crops that tend to accumulate F, should be reduced as much as possible. It is therefore very important, if possible, not to irrigate crops with F-contaminated irrigation water. However, in areas F-contaminated irrigation water, it is advisable to grow crops with relatively low capabilities to enrich F, such as those with seeds or tubers as the main edible parts.

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