Fluoride contamination and fluorosis in Gaya Region of Bihar, India

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Fluorine is the lightest member of the halogen group and is one of the most reactive of all chemical elements. Fluorine in the environment is therefore found as fluorides which together represent about 0.06–0.09 per cent of the earth’s crust (WHO 2006). Fluorides are found at significant levels in a wide variety of minerals, including fluorspar, rock phosphate, cryolite, apatite, mica, hornblende and others (Murray, 1986). In groundwater, low or high concentrations of fluoride can occur, depending on the nature of the rocks and the occurrence of fluoride-bearing minerals. High fluoride concentrations may be expected in groundwater from calcium-poor aquifers and in areas where fluoride-bearing minerals are common (Edmunds and Smedley, 1996). Waters with high fluoride concentrations occur in large and extensive geographical belts associated with a) sediments of marine origin in mountainous areas, b) volcanic rocks and c) granitic and gneissic rocks. High groundwater fluoride concentrations associated with igneous and metamorphic rocks such as granites and gneisses have been reported from India, Pakistan, West Africa, Thailand, China, Sri Lanka, and Southern Africa.

Fluoride has beneficial effects on teeth at low concentrations in drinking water, but excessive exposure to fluoride in drinking water can give rise to a number of adverse effects. These range from mild dental fluorosis to crippling skeletal fluorosis as the level and period of exposure increases (WHO, 2006). The permissible upper limit of fluoride in a tropical country like India is 1.00 ppm (mg /l) and this is the standard for fluoride issued by the Bureau of Indian Standards (BIS) for drinking water (1992).

A total of 17 (out of 32) States of India are reported to have endemic fluorosis, namely; Andhra Pradesh, Assam, Bihar, Delhi, Gujarat, Haryana, Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. (FRRDF, 1999; Yadav et al., 1999). According to Susheela (1987), 30-50% of districts of Bihar are affected by fluorosis. Unfortunately, there is no published record of studies on this aspect from Bihar except that of Kachgariadih village under Rajauli block of Bihar (Khandare et al., 2005). Various organizations such as PHED, UNICEF and water development boards are working on this issue and have discovered that fluorosis is endemic in Gaya. Therefore, the present study was undertaken to estimate the fluoride (F) level in groundwater and to determine the extent of fluorosis in three selected villages of Gaya where ground water is the main source of drinking water. Also, the study relates the occurrence of fluorosis with nutritional aspects of the study subjects.

Gaya is a city in Bihar, India, and it is also the headquarters of Gaya District. It is situated 100 kilometers South of Patna, the capital of Bihar. Its geographical location is at 24° 41’ 45’’ N. Latitude and 85° 2’ 22’’ E. Longitude. Three villages of Gaya District i.e. Jori, Islampur and Chotki Nawada were selected for the study. The villagers are poor, depend entirely on casual labour for
their livelihood and suffer from various degrees of malnutrition.

Drinking water sources in the study area included the hand pump water. Water samples were analysed for F in the field using the instrument, SPECTROQUANT NOVA 60 and F kit of MERCK make. Thirty households were surveyed using a predesigned questionnaire. Information was collected on the following aspects: monthly income, source of water, daily diet, health problems, and awareness about fluorosis.

Sixty six samples of drinking water (hand pump as source) were analyzed at the three villages of Gaya and nine water samples were analyzed from Gaya town. It was found that F level was high in all the 66 samples collected from the villages. The water samples from Gaya town had F concentration within the permissible limits. The highest F concentration of 14.4 and 14.3 mg/L was found in the two villages, Jori and Chotki Nawada, respectively. However, the mean F level was highest (8.6 mg/L) at Islampur (Table 1). Maximum number of households were affected by F in the range 3-9 mg/L (Table 2). Such a high F level in drinking water might have caused serious health problems in the villagers. A detailed health survey is required to throw light on this aspect.

Choubisa et al. (1997) found that at mean fluoride concentrations of 6 mg/L, dental fluorosis was seen in 84.4 per cent of school children (< 16 years) and 96.9 per cent of adults. Yadav and Lata (2003) examined the prevalence of dental fluorosis at lower drinking-water fluoride concentrations (mean concentrations between 1.93 and 2.14 mg/L) in the Jhajjar district, Haryana and found that over 50 per cent of the children examined were found to be affected by dental fluorosis. Reddy and Prasad (2003) reported dental fluorosis levels of 43 per cent in the Anantapur district of Andhra Pradesh, where drinking water fluoride concentrations ranged between 1.2 and 2.1 mg/L.

In the present study 30 households were surveyed, 20 belonged to low income, poor diet group and 10 belonged to relatively higher income, better diet group. The occurrence of fluorosis was found to be higher in the former group, although both the groups were exposed to roughly the same F level in ground water (Table 3). It is suggested that the presence of calcium, protein and vitamin C in food has preventive role in fluorosis (WHO 1984; Boyd and Cerklewski, 1987; Gupta, 1999). A very recent study also found that individuals using citrus fruits and having good nutritional status suffer least with fluorosis (Hussain et al., 2009).

CONCLUSION

The present study provided preliminary data on the fluoride contamination and fluorosis in Gaya region of Bihar. It was evident that the people who live below the poverty line are highly susceptible to fluorosis. Further monitoring of water samples and health status of villagers in fluoride endemic areas of Gaya district is required to appraise the government, so that defluoridation plants can be installed. Further, the villagers have to be made aware of the causes and effects of fluorosis, its remediation through search of safe drinking water such as rainwater harvesting.

ACKNOWLEDGEMENTS

We are grateful to University Grants Commission for providing financial assistance under the scheme of Basic Scientific Research for undergraduate students. We also thank Dr. S. N. Singh, CEO, UNICEF, Patliputra and Dr. A.K. Sinha, PHED, Gaya for their cooperation and support.
Table 1: Fluoride levels at different villages of Gaya district.

<table>
<thead>
<tr>
<th>Village</th>
<th>No. of samples</th>
<th>Range of Fluoride (mg/L)</th>
<th>Mean (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jori</td>
<td>20</td>
<td>3.5 – 14.4</td>
<td>7.5</td>
</tr>
<tr>
<td>Chotki Nawada</td>
<td>12</td>
<td>3.18 – 14.3</td>
<td>5.6</td>
</tr>
<tr>
<td>Islampur</td>
<td>34</td>
<td>3.13 – 11.2</td>
<td>8.6</td>
</tr>
<tr>
<td>Gaya town</td>
<td>9</td>
<td>0.19 – 1.77</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Table 2: Fluoride range and households affected at three villages Jori, Islampur and Chotki Nawada of Gaya district (Bihar)

<table>
<thead>
<tr>
<th>Range of Fluoride mg/L</th>
<th>No. of households affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>9</td>
</tr>
<tr>
<td>3-6</td>
<td>26</td>
</tr>
<tr>
<td>6-9</td>
<td>27</td>
</tr>
<tr>
<td>9-12</td>
<td>11</td>
</tr>
</tbody>
</table>

No. of samples = 75
### Table 3: Relation between income, diet and impact of fluorosis

<table>
<thead>
<tr>
<th>Range of fluoride (mg/L)</th>
<th>No. of families surveyed</th>
<th>Average Age ± S.E</th>
<th>Ratio* of adults to children</th>
<th>Monthly Income (Rs)</th>
<th>Diet</th>
<th>No. of Families suffering with</th>
<th>Dental fluorosis</th>
<th>Skeletal fluorosis</th>
<th>Joint pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5 - 14.4</td>
<td>20 (77 persons)</td>
<td>27.9 ±2.1</td>
<td>1.5:1</td>
<td>1000 - 3000</td>
<td>Only Cereals</td>
<td>16</td>
<td>2 significant cases found</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>3.18 - 14.3</td>
<td>10 (32 persons)</td>
<td>28.3±2.4</td>
<td>2:1</td>
<td>3000 - 6000</td>
<td>Cereals, milk, citrus fruits, carrots, eggs, if not always, at least very often</td>
<td>4 families with yellow coat on teeth</td>
<td></td>
<td>None</td>
<td>4</td>
</tr>
</tbody>
</table>

*Adults = >18 years; children = 5-18 yrs; infants (0-5 years) were not considered.
REFERENCES


[MS received 24 May 2011; MS accepted 18 August 2011]

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