ENDEMIC FLUOROSIS IN FIVE VILLAGES OF THE PALAMAU DISTRICT, JHARKHAND, INDIA

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SUMMARY: Chronic fluoride intoxication in the form of dental and skeletal fluorosis was surveyed in five villages of the Palamau district, Jharkhand, India. Out of 238 sources of drinking water, mainly from groundwater, the majority had elevated fluoride concentrations capable of causing health risk to the community. In one water source a concentration of 12 mg F/L was observed. Dietary intake of fluoride through food, however, was much less significant compared with drinking water. Among the children, 83% were diagnosed with dental fluorosis, and 47% of adults were afflicted with various stages of skeletal fluorosis. A level of 2.5 mg F/L was found to be a critical threshold for manifestations of crippling skeletal fluorosis. Household defluoridation along with improved nutrition rich in calcium is recommended for amelioration of fluorosis in these villages.

Keywords: Dental fluorosis; Dietary fluoride intake; Endemic fluorosis; Groundwater fluoride; Palamau, Jharkhand, India; Skeletal fluorosis; Water quality standards.

INTRODUCTION

Chronic fluorosis is a world-wide problem.[1-4] Endemic fluorosis has been identified in 20 states of India.[5-7] About 62 million people, including 6 million children are at risk in India suffering from dental, skeletal and/or non skeletal fluorosis.[8] Excess fluoride (F) concentration in drinking water is a major cause of fluorosis in India. The safe limit of 1.5 mg F/L recommended by the World Health Organization in drinking water is increasingly debated and contested in the light of recent scientific evidence.[9]

F-containing minerals are widely distributed, and leaching of F from rocks is the major cause of high F concentrations often found in groundwater in India. Although fluorosis is well documented in the states of Rajasthan, Andhra Pradesh, Bihar, and several others,[10] few studies on the occurrence of F have been undertaken or reported in the Palamau district of the state of Jharkhand, India, which is known to be endemic for fluorosis.

The present study was therefore undertaken to determine the extent of fluorosis in five selected villages in Palamau where groundwater is the major source of drinking water. Various mitigation measures are also addressed as part of this study.

MATERIALS AND METHODS

Study Area: The five villages of Ganke, Mukhiya Tola, Satyari Tola, Chukru, and Bakhari in the Palamau district of Jharkhand were selected for study (Figure). In these villages, groundwater is the main source of drinking water. Socioeconomic conditions are very poor, and the villagers, who depend entirely on agriculture and

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casual labor for their livelihood, suffer from various degree of malnutrition. Out of ten F-affected villages, the five mentioned were selected for the current study on the basis of the severity of symptoms of endemic fluorosis.

*Analysis of groundwater***:** Drinking water sources assessed for F concentration include the hand pump, dug well, and river water in the five selected villages. Water samples were analyzed for F within 24 hr of collection in the field laboratories in the study area. An ion specific F electrode (Orion 290 A+) was used in the field laboratory with TISAB-II solution in a 1:1 volume ratio with the samples. F in vegetables and foods was analyzed by extracting with sodium hydroxide solution following the procedure of Zhou et al.[11]

For conducting the health survey, the necessary questionnaire was developed to correlate with the drinking water source and its F, dietary practice, and socioeconomic conditions.

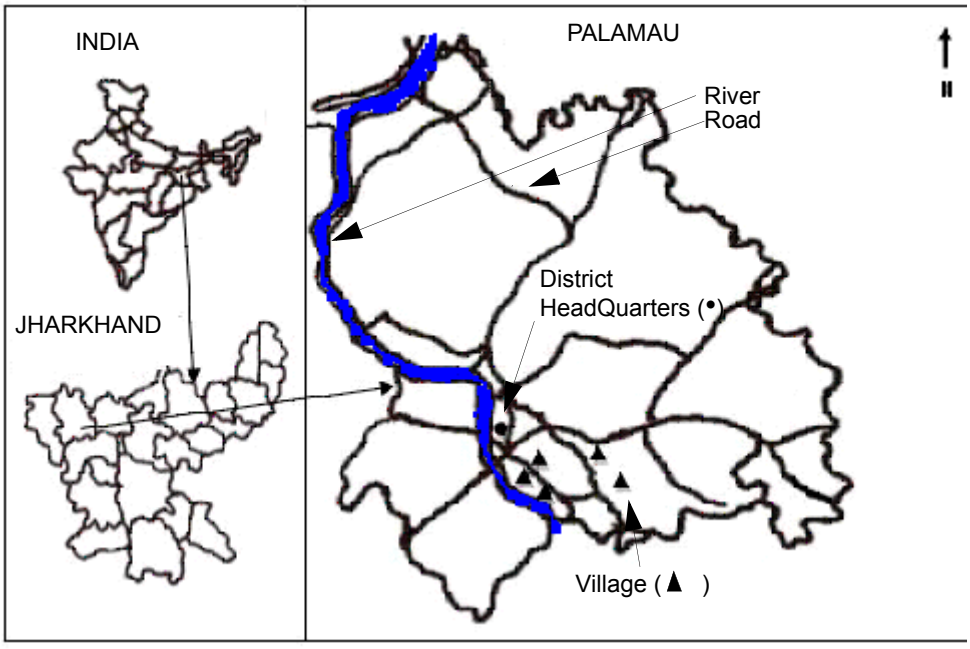

Figure. Map of Palamau District, Jharkhand, showing the location of villages

RESULTS AND DISCUSSION

Of the 238 drinking water sources in the five affected villages that were analyzed for F, the mean F concentration was higher in all of them than the desirable limit of 1.0 mg F ion/L for safe drinking water. The highest F concentration of 12 mg/L was detected in five water sources in Chukru and Andharbagh villages (Table 1). The F concentration did not show any appreciable variation between open wells and hand pumps. Moreover, unlike earlier studies by Teotia et al.,[12] the depth of the groundwater seemed to have little affect on the F level in the water. High concentrations of F in these water sources can be attributed to dissolution from bed rocks by geochemical processes.

Table 1. F concentration in drinking water sources in five selected villages of the Palamau district

Site No.	Village/Hamlet	No. of existing sources	No. of sources monitored	Range of F concentration (mg/L)	Mean	Standard deviation (±SD)
1	Ganke	37	33	0.10 – 3.60	1.51	1.02
2	Satyari					
2.1	Satyari Tola	25	21	0.49 – 3.51	1.89	0.79
2.2	Andharbagh	18	16	1.68 – 7.29	4.39	1.40
3	Mukhiya					
3.1	Mukhiya Tola	39	31	0.12 – 4.11	2.50	0.99
3.2	Lalmatiya Tola	9	9	0.30 – 3.68	2.69	1.01
4	Bakhari	60	57	0.28 – 12.30	3.71	2.45
5	Chukru	75	71	0.98 – 9.68	2.91	1.56

Dietary intake of F through foods: Dietary intake of F from food stuffs was calculated on the basis of the average amounts of different types of food eaten in the community. As recorded in Table 2, the estimated total F intake by adults from food stuffs is about 1.23 mg/day in Chukru, 1.15 mg/day in Bakhari, and 0.97mg/ day in Ganke. Note that F intake from pulses and cereals is considerably greater than from vegetables. Even so, dietary intake of F appears to be less significant compared to ingestion from water.

Table 2. Estimated dietary intake of F through foods in three villages of the Palamau district

Site No.	Major dietary item	Average intake of Item (g/day)	Average F content (mg/kg)	Intake of F (mg/day)
1	Chukru village			
i	Cereals	500	1.78	0.89
ii	Pulses	100	2.28	0.23
iii	Vegetables	500	0.23	0.11
			Total	1.23
2	Bakhari village			
i	Cereals	500	1.74	0.87
ii	Pulses	100	1.81	0.18
iii	Vegetables	500	0.20	0.10
			Total	1.15
3	Ganke village			
i	Cereals	500	1.50	0.75
ii	Pulses	100	1.46	0.15
iii	Vegetables	500	0.14	0.07
			Total	0.97

Impact of F concentration in drinking water and fluorosis: About 190 households were surveyed in the five selected villages comprising of 420 males and 398 females including 345 children below 18 years of age. From the data collected it is clear that severe skeletal fluorosis occurs in the villages where the drinking water contains more than 2.5 mg F/L and below this concentration dental fluorosis is found to be widespread in the communities (Tables 3 and 4).

Table 3. Occurrence of dental fluorosis among children living in five villages of the Palamau district

Site No.	Village	No. of children surveyed	Affected with dental fluorosis				
			Mild	Moderate	Severe	Total	%
1	Ganke	45	21	3	–	24	53
2	Satyari						
2.1	Satyari tola	13	5	–	–	5	38
2.2	Andharbagh tola	28	6	18	–	24	86
3	Mukhiya						
3.1	Lalmathiya tola	18	6	7	1	14	78
3.2	Mukhiya tola	34	15	13	2	30	88
4	Bakhari	88	77	6	1	84	95
5	Chukru	119	105	1	–	106	81
	Total	345	235	48	4	287	83.2

Table 4. Occurrence of skeletal fluorosis among adults living in five villages of the Palamau district

Site No.	Village	No. of adults surveyed	Affected with skeletal fluorosis				
			Mild	Moderate	Severe	Total	%
1	Ganke	85	22	4	1	27	32
2	Satyari						
2.1	Satyari tola	49	22	2	–	24	49
2.2	Andharbagh tola	54	13	5	4	22	41
3	Mukhiya						
3.1	Lalmathiya tola	34	15	2	–	17	50
3.2	Mukhiya tola	81	21	15	1	37	46
4	Bakhari	238	106	20	3	129	54
5	Chukru	277	116	14	2	132	48
	Total	818	315	62	11	388	47.4

As seen in Table 3, among the 345 children surveyed in the five villages, 287 (83.2%) were affected by detectable dental fluorosis. Among 818 adults, 388 (47.4%) were affected by various stages of skeletal fluorosis (Table 4). From the data in Table 4 it is evident that F concentrations exceeding 2.5 mg F/L in the drinking water appear to be critical for manifestation of severe forms of skeletal fluorosis in the subjects. Malnutrition because of poverty and diets deficient in calcium and vitamin C are known to aggravate symptoms of fluorosis. Habitual consumption of excess amounts of tea and tobacco-based items were observed in all age groups, and these substances often contain elevated levels of F, thereby increasing the body burden of F in already affected subjects. The average estimated intake of F from water used for drinking and cooking in each village by many typical malnourished adults weighing 52 kg is given is Table 5.

Table 5. Estimated average F intake by adults from water (drinking and cooking) in villages of the Palamau district

Site No.	Village	Population	Average water F content (mg/L)	Intake of F (mg/day) from water (7 L/day for a 52-kg adult)
1	Ganke	403	1.51	10.57
2	Satyari			
2.1	Satyari Tola	282	1.89	13.23
2.2	Andharbagh Tola	174	4.39	30.73
3	Mukhiya			
3.3	Lalmathiya tola	144	2.69	18.83
3.2	Mukhiya tola	564	2.50	17.5
4	Bakhari	897	3.71	25.97
5	Chukru	600	2.91	20.37

The adoption of a lower drinking water standard for F than that recommended by the World Health Association is desirable in India where, because of the hot climate with a mean annual temperature as high as 38^{o}C, water consumption is very high. The occupation of the majority of people living in the rural Palamau areas of Jharkhand is farming, where many of the working adults consume an average of 7 liters of water per day including water used for cooking. The native diet is semisolid and starchy, containing substantial amounts water. Cooking requires ca. 2 L of water/day with a staple Indian diet consisting mostly of cereals and pulses. High levels F intake have long been associated with various forms of debilitating fluorosis.[13]

A major challenge that remains to be addressed at the policy level in India and other countries of Southeast Asia is to develop and implement realistic national drinking water standards based on existing and available scientific evidence rather than over-reliance on standards recommended by WHO. In our view, a community-based water defluoridation strategy adopted as a part of this project should include imparting awareness of the ill effects from F in drinking water and promoting domestic defluoridation with household activated alumina filters and setting up a recharging center for them in each village.

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