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Study of Fluoride Contribution Through Water and Food to Human Population in Fluorosis Endemic Villages of North-Eastern Rajasthan

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Abatract: Exposure to fluoride through water and food has adversely affected the human health resulting in dental and skeletal fluorosis. Groundwater with high fluoride occurs in large parts of Africa, China, Middle-East and Southern Asia. Taking into account the contribution of fluoride through drinking water and food, the quantum fluoride exposure of the population in selected fluorosis endemic villages was assessed. Socio-economic and dietary surveys were also conducted as part of impact assessment studies. Fluoride concentrations in groundwater samples of 10 endemic villages varied from 1.50 to 11.82 mg/L, which was much beyond the WHO permissible limit of 1.5 mg/L. The fluoride content in vegetables and cereals varied between 3.91 to 29.15 µg/g and 0.45 to 5.98 µg/g respectively. Fluoride content in milk samples was generally low and found to vary from 0.37 µg/ml in goat's milk to 6.85 µg/ml in buffalo's milk. Prevalence of dental, skeletal fluorosis and non-skeletal manifestations viz. loss of appetite, abdominal pain, nausea, insomnia, polyuria and paralysis, was observed in these villages. Results strongly suggest that ground water in fluorosis endemic areas is a major contributing factor to total fluoride ingestion, either when used for drinking or cooking purposes.

Key words: Fluoride · Dental fluorosis · Skeletal fluorosis · Groundwater · Endemic

INTRODUCTION

Fluorosis is an endemic health problem in many parts of the world particularly in the mid-latitude regions and its several forms including skeletal fluorosis have been reported worldwide. Fluorosis is a major public health problem in 18 out of 32 constituent states of India [1]. The concentration of fluoride in groundwater depends on the concentration of fluoride bearing minerals in the rock types and mainly depends on the decomposition and dissolution activities through rock fluoride interactions. Susheela [1] reported that groundwater is rich in fluoride around the mica mines and Rajasthan as a rich source of mica mines has groundwater with high fluoride concentration.

The onset of fluorosis and the severity of symptoms are governed by chronic fluoride ingestion, the most important being quantity of fluoride ingested and duration of exposure. Apart from drinking water, food grown in endemic regions also serves as source of fluoride. Bassin *et al*., [2] reported high intake of fluoride through drinking water which is about 70% while through food is 30%. Fluoride and calcium interact in a negative manner and a study has also indicated that calcium intake through diet decreases the retention of fluoride in bones [3]. The percentage of calcium in vegetables, cereals and fruits varies considerably, while milk is known to be the richest source of calcium, therefore these food items considerable decreases the effect of fluorosis.

The research in India also provides ample evidence on the critical roles of malnutrition and poverty on the incidence and severity of fluorosis. Depending upon the level of excessive fluoride exposure, the affected population suffers from dental or skeletal fluorosis [4]. The aim of the present study is to assess the fluoride exposure through water, food and milk on residents of selected villages in North-Eastern Rajasthan.

MATERIALS AND METHODS

Analysis of Drinking Water and Food Samples

Estimation of Fluoride in Water: Groundwater samples were collected from 10 villages (Ajitpura, Suraj Ka Kheda, Brijlalpura, Pathraj, Jagatpura, Choriya, Nohata, Pahadi, Bhakawa and Jodhpuria) of Niwai region in Tonk district, Rajasthan (India). These samples were analyzed for fluoride by ion-selective electrode method [5].

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Estimation of Fluoride in Food Items and Milk Samples: Vegetables, cereals and fodder grown in fluoride endemic villages and irrigated with groundwater containing high fluoride were collected in polyethylene containers and brought to laboratory. Similarly, milk samples of goat, cow and buffalo were taken from fluorosis endemic villages. Fluoride content in the sample of food items and milk samples were estimated by Potentiometric method [6].

Dietary and Socio-economic Surveys: Dietary surveys were conducted using a family dietary schedule cum interview method. Size of the family, educational status and family income were taken into account to determine the socio-economic status of people in the study area.

RESULTS AND DISCUSSION

In Rajasthan, first case of skeletal fluorosis was reported in Jobner near Jaipur by Kasliwal and Saloman [7]. Later Mathur *et al*., [8] reported the prevalence of fluorosis in Ajmer district. Fluoride concentration in groundwater samples (Hand-pumps, Tube-wells and Wells) of villages assessed, was found to vary from minimum 1.5 mg/L to maximum 11.82 mg/L (Table 1), while the permissible limit of fluoride is 1.5 mg/L [9]. This is an indication of the fact that a large number of people residing in these villages of Rajasthan are exposed to high fluoride toxicity.

Table 1: Fluoride concentration in groundwater samples

Name of village	Fluoride concentration (mg/L)
Ajitpura	5.80 - 11.82
Suraj Ka Kheda	9.76 -10.76
Brijlalpura	3.86 - 6.20
Pathraj	3.54 - 8.00
Jagatpura	1.50 -6.00
Choriya	2.51 - 4.21
Nohata	2.50 - 4.20
Pahadi	1.50 - 3.96
Bahakawa	4.21 - 4.92
Jodhpura	4.00 - 4.80

From the study of fluoride content in vegetables, cereals and fodder (Table 2) it was found that leafy vegetables are rich sources of fluoride when they are irrigated with groundwater having high fluoride

Table 2: Fluoride content in vegetables, cereals and fodder

S. No.	Name of village	Range of fluoride (mg/L) in groundwater	Raw food items	Fluoride content in food items (µg/g) (Mean±S.E.)
1.	Ajitpura	5.80-11.82	Wheat	5.04±0.15
			Spinach	29.15±0.03
			Cabbage	11.30±0.03
			Cauliflower	12.09±0.14
2.	Suraj Ka Kheda	9.76-10.76	Wheat	4.95±0.09
			Lady's finger	22.19±0.09
			Fodder	1.45±0.04
			Spinach	17.53±0.08
3.	Brijlalpura	3.86-6.20	Carrot	10.75±0.04
			Spinach	10.95±0.10
			Onion	10.50±0.09
			Chana	3.26±0.06
			Wheat	5.98±0.15
4.	Pathraj	3.54-8.00	Barley	3.65±0.04
			Wheat	3.63±0.04
			Mustard leaves	14.59±0.13
5.	Jagatpura	1.50-6.00	Spinach	18.98±0.09
			Carrot	5.88±0.07
			Cabbage	10.75±0.09
			Fodder	2.16±0.08
6.	Choriya	2.51-4.21	Cabbage	4.56±0.10
			Raddish leaves	9.16±0.09
			Onion	5.67±0.10
			Wheat	3.40±0.09
7.	Nohata	2.50-4.20	Wheat	3.65±0.06
			Mustard leaves	12.66±0.25
			Raddish leaves	14.96±0.16
			Potato	11.95±0.53
			Tomato	13.48±0.08

Table 2: Continued

8.	Pahadi	1.50-3.96	Cabbage	4.25±0.10
			Spinach	9.87±0.07
9.	Bahakawa	4.21-4.92	Cabbage	3.91±0.04
			Wheat	0.51±0.03
			Spinach	9.95±0.03
10.	Jodhpura	4.80-4.90	Barley	0.45±0.01
			Spinach	14.11±0.07
			Red chilli	7.92±0.06
			Fodder	1.89±0.05

Table 3: Fluoride Content in milk samples in study area

S. No.	Name of Village	Range of fluoride (ppm) in ground water	Fluoride in Buffalo's milk (µg/ml)	Fluoride in cow's milk (µg/ml)	Fluoride in goat's milk (µg/ml)
1.	Ajitpura	5.80-11.82	*	5.012±0.05	2.062±0.03
2.	Suraj Ka Kheda	9.76-10.79	6.850±0.15	4.662±0.05	1.263±0.02
3.	Brijlalpura	3.86-6.20	*	4.687±0.09	0.962±0.14
4.	Pathraj	3.54-8.00	*	6.875±0.15	0.937±0.04
5.	Jagatpura	1.50-6.00	4.787±0.04	3.575±0.16	*
6.	Choriya	2.51-4.21	4.225±0.16	1.987±0.11	0.700±0.05
7.	Nohata	2.50-4.20	4.387±0.08	1.737±0.13	0.415±0.01
8.	Pahadi	1.50-3.96	3.321±0.11	3.321±0.14	0.537±0.05
9.	Bahakawa	4.21-4.92	3.376±0.11	2.521±0.08	*
10.	Jodhpura	4.80-4.90	3.425±0.08	3.425±0.05	0.375±0.03

* Samples could not be obtained as the specific animals were absent in the particular village

concentrations. Leafy vegetables viz. Raddish leaves (*Raphanus sativus*) Spinach leaves (*Spinacea oleoracea*) and mustard leaves (*Brassica compestris*) were found to accumulate 14.96 µg/g, 29.15 µg/g and 14.59 µg/g fluoride respectively, which were irrigated with water having 3.54 mg/L to 11.82 mg/L fluoride. Researchers have reported that vegetables, exposed to air borne fluoride, absorb it in their laminae [10].

Cereals were found to accumulate lower fluoride. Highest fluoride content was estimated in wheat (*Tritium aestivum*) (5.98 µg/g) which was irrigated with water having 6.20 mg/L fluoride concentration. Barley (*Hordeum vulgare*) and Chana (*Cicer arietinum*) grains accumulated lower fluoride content (0.45-3.95 µg/g). Fodder containing wheat and barley straws accumulated least quantities of fluoride (1.45-2.16 µg/g).

Milk of buffaloes, cows and goats were also collected from these villages and highest content of fluoride was observed in buffalo's milk (6.85 µg/ml) of Suraj Ka Kheda village and lowest in goat's milk (0.37 µg/ml) of Jodhpura village.

Kabasakalis *et al*., [11] reported that fluoride has the tendency to be accumulated in the vegetable leaves. In our study, we also observed that fluoride content was very high in the raddish and spinach leaves. Fluoride content was also estimated in other vegetables like onion, carrot, lady's finger and chilli and highest was recorded in lady's finger (22.19 µg/g) from Suraj ka Kheda village. It was irrigated with water having 9.76 mg/L fluoride concentration. Fluoride content was lower in cereals even irrigated with high fluoride water. From the study, it was inferred that fluoride content in food items varied from place to place depending on the fluoride concentration in irrigation water and soil. It also depends on fluoride tolerance and accumulation capacity of plants. Fluoride content in milk samples collected from fluorosis endemic villages was generally low. Cattle from fluorosis endemic villages consuming high fluoride water had low fluoride in milk though fluoride content in buffalo's milk was highest and that of goat's milk was lowest from same region. The fact that low content of fluoride is observed in milk from low as well as high fluoride areas shows that there is a limited transfer of fluoride to breast milk.

The dietary fluoride intake excess of 0.1 mg/kg body weight has been generally accepted to cause dental fluorosis and intake levels from 0.05 to 0.07 mg/kg body weight is optimal for dental health of children form 1 -12 years [12,13,14].

Socio-economic surveys revealed that most of the people in these areas are below poverty line with farming and animal rearing as their major occupation. Malnutrition and ill-balanced diet was reported in all the endemic villages with regular consumption of habit-making substances like tobacco by large number of adult males and females.

Our study concludes that ground water in fluorosis endemic areas might be a major contributing factor to total fluoride ingestion, either when used for drinking or cooking purposes. Calcium ingestion is known to reduce intestinal absorption of fluoride so diets rich in calcium, magnesium and vitamin-C are recommended to prevent fluorosis. The currently available techniques for defluoridation of water like Nalgonda technique, activated alumina adsorption, reverse-osmosis and nano-filteration should be effectively applied in fluorosis endemic rural areas with constant monitoring and there is an urgent need for defluoridation of water used for drinking and in irrigation to prevent fluorosis.

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