Review Article

www. ijrdh.com
ISSN: 2321 – 1431

Fluorosis in India: an overview

COMMUNITY MEDICINE

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Introduction:

Fluorine is the most abundant element in nature, and about 96% of fluoride in the human body is found in bones and teeth. Fluorine is essential for the normal mineralisation of bones and formation of dental enamel [1].The principal sources of fluorine was drinking water and food such as sea fish, cheese and tea [2]. The recommended level of fluoride in drinking water in India is 0.5 to 0.8 mg/l [3].

Fluorosis is an important public health problem in 24 countries, including India, which lies in the geographical fluoride belt that extends from Turkey to China and Japan through Iraq, Iran and Afghanistan [4]. Of the 85 million tons of fluoride deposits on the earth's crust, 12 million are found in India [5]. Hence it is natural that fluoride contamination is widespread, intensive and alarming in India. Endemic fluorosis is prevalent in India since 1937 [6]. It has been estimated that the total population consuming drinking water containing elevated levels of fluoride is over 66 million [7]. Endemic fluorosis resulting from high fluoride concentration in groundwater is a public health problem in India [8].

The available data suggest that 15 States in India are endemic for fluorosis (fluoride level in drinking water >1.5 mg/l), and about bout 62 million people in India suffer from dental, skeletal and non-skeletal fluorosis. Out of these; 6 million are children below the age of 14 years [9]. Groundwater is considered as the major source of drinking water in most places on earth [10].

India was one of the worst fluorosis affected countries, with large number of people suffering. This is because a large number of Indians rely on groundwater for drinking purposes and water at many places is rich in fluoride [11]. In India 62 million people including 6million children are estimated to have serious health problems due to consumption of fluoride contaminated water [12].

World Health Organization (WHO) has set the upper limit of fluoride concentration in drinking water at 1.5 mg/l [13], and The Bureau of Indian Standards, has therefore, laid down Indian standards as 1.0 mg/l as maximum permissible limit of fluoride with further remarks as "lesser the better" [14]. Intake of fluoride higher than the optimum level is the main reason for dental and skeletal fluorosis.

The main source of fluoride in groundwater is the rocks which are rich in fluoride. Most of the people affected by high fluoride concentration in groundwater live in the tropical countries where the per capita consumption of water is more because of the prevailing climate [10]. Some regions in north western and southern India are heavily affected with fluorosis [15,16]. Similarly, the rocks in southern India are rich with fluoride which forms the major reason for fluoride contamination in groundwater [10], and the granites in the district of Nalgonda, Andhra Pradesh contain much higher fluoride than the world average fluoride concentration of 810 mg/kg [17].

Fluorine is often called as two-edged sword. Prolonged ingestion of fluoride through drinking water in

excess of the daily requirement is associated with dental and skeletal Fluorosis. Similarly, inadequate intake of fluoride in drinking water is associated with dental caries [1].

Dental Fluorosis

Tooth enamel is principally made up of hydroxyapatite (87%) which is crystalline calcium phosphate [18].

Fluoride which is more stable than hydroxyapatite displaces the hydroxide ions from hydroxyapatite to form fluoroapatite. Fluorosis of dental enamel occurs when excess Fluoride is ingested during the years of tooth calcification-essentially during the first 7 years of life. It is characterised by mottling of dental enamel, which has been reported at levels above 1.5 mg/L intake [19].

On prolonged continuation of this process the teeth become hard and brittle. This is called dental fluorosis. Dental fluorosis in the initial stages results in the tooth becoming coloured from yellow to brown to black. Depending upon the severity, it may be only discolouration of the teeth or formation of pits in the teeth. The colouration on the teeth may be in the form of spots or as streaks. Dean's classification of dental fluorosis is presented in Table-1.

Table 1: Criteria for Dean's Fluorosis Index [20]

Score	Criteria
Normal	The enamel represents the usual translucent semivitriform type of structure. The surface is smooth, glossy, and usually of a pale creamy white colour.
Questionable	The enamel discloses slight aberrations from the translucency of normal enamel, ranging from a few white flecks to occasional white spots. This classification is utilized in those instances where a definite diagnosis of the mildest form of fluorosis is not warranted and a classification of "normal" is not justified.
Very Mild	Small opaque, paper white areas scattered irregularly over the tooth but not involving as much as 25% of the tooth surface. Frequently included in this classification are teeth showing no more than about 1-2 mm of white opacity at the tip of the summit of the cusps of the bicuspids or second molars.
Mild	The white opaque areas in the enamel of the teeth are more extensive but do not involve as much as 50% of the tooth.
Moderate	All enamel surfaces of the teeth are affected, and the surfaces subject to attrition show wear. Brown stain is frequently a disfiguring feature.
Severe	Includes teeth formerly classified as "moderately severe and severe." All enamel surfaces are affected and hypoplasia is so marked that the general form of the tooth may be affected. The major diagnostic sign of this classification is discrete or confluent pitting. Brown stains are widespread and teeth often present a corroded-like appearance.

The prevalence of dental fluorosis in various geographical regions of India is presented in Table-2.

Table 2: Prevalence (%) of dental fluorosis in different parts of India by age groups

State/Area	Age-group (Years)	Prevalence (%)	Author
Cuddalore, TN	5-12	31.4	Sarvanan et.al. Indian J Community Med. 2008; 33(3): 146–150.
Alapuzzha, kerala	10-17	35.6	Gopalakrishnan et.al. Natl Med J India. 1999; 12(3):99-103.
Vadodara, Gujarat	Adults	39.2 - 59.3	Kotecha et al. Indian J Med Res. 2012 June; 135(6): 873–877.
Davangere, karnataka	12-15	13-100	Chandrasekhar and Anuradha. Int Dent J. 2004; 54(5):235-9.
Jhajjar, Haryana	7-15	30-94.9	Yadav et al. Environ Geochem Health. 2009; 31(4):431-8.
Birbhum, West Bengal	Adults	61-66.7	Majumdhar. Indian J Public Health 2011; 55:303-8.
Punjab	5-60	91.1	Shashi and Bhardwaj. Biosci. Biotech. Res. Comm. 2011; 2:155-163.
Nalgonda, A.P	12-15	71.5	Shekar et al. Indian J Public Health. 2012; 56(2):122-8.
Durg, Chattisgarh	Adults	8.2	Pandey. Trop Doct. 2010; 40(4):217-9.
Dungarpur, Udaipur (Rajasthan)	All ages	39.2-72.1	Choubisa et al. J Environ Sci Eng. 2010; 52(3):199-204.
Palamau Jharkhand	children	83.2	Srikanth et al. Research report Fluoride. 2008; 41(3)206–211.
Assam	All ages	31.3	Chakraborti et al. Current Science. 2000; 78 (12): 1421-1423.
Uttar Pradesh	All ages	28.6	Srivastava et al. Int J Oral & Maxillofacial Pathology; 2011:2(2):7-12.
Kareka, Shivpuri Madhya Pradesh	13-50	86.8	Saksena and Narwaria. Int j Environ Sci. 2012; 3(3).
Raigad, Maharashtra	0-23	91.7	Bawaskar and Bawaskar. Trop Doct. 2006; 36: 221.
Nalgonda, A.P	Adults	30.6	Nirgude et al. Indian J Public Health. 2010;54(4):194-6.

Skeletal fluorosis

Exposure to very high fluoride over a prolonged period of time results in acute to chronic skeletal fluorosis. It was stated in 1993 that crippling skeletal fluorosis might occur in people who have ingested 10 to 20 mg of fluoride per day for over 10 to 20 years [21]. Early stages of skeletal fluorosis start with pain in bones and joints, muscle weakness, sporadic pain,

stiffness of joints and chronic fatigue. During later stages, calcification of the bones takes place, osteoporosis in long bones, and symptoms of osteosclerosis where the bones become denser and develop abnormal crystalline structu re. In the advanced stage the bones and joints become complet ely weak and moving them is difficult. The vertebrae in thespi ne fuse together and the patient is left crippled which is the final stage. Skeletal fluorosis is usually not recognized until the disease reaches an advanced stage [10]. General skeletal fluorosis directly affects the economy of villagers (mostly tribal population) as it causes illness and debilitation not only in humans but, also in their domestic animals, on which they depend for their basic income [22]. Skeletal fluorosis leads to impairment, disability and subsequently makes the affected subject handicap. Therefore, they are unable to get employment or labour for their daily livelihood, lead their life as dependents on others. Similarly, the skeletal fluorosis affected youth were at extremely difficult situation, where they were unable to find alliance from non-fluoride affected villages, thus, they are forced to marry the youth from the same or fluoride affected villages. The prevalence of skeletal fluorosis in various geographical regions of India is presented in Table-3.

Table 3: Prevalence (%) of skeletal fluorosis in different parts of India by age groups

State/Area	Age group	Prevalence (%)	Author
Nalgonda, Andhra pradesh	All ages	24.9	Nirgude et al. Indian J Public Health. 2010 Oct-Dec; 54(4):194-6.
Durg, Chattisgarh	Adults	6.3- 38.1	Pandey. Trop Doct. 2010; 40(4):217-9.
Dungarpur and Udaipur Rajasthan	All ages	12-27.6	Choubisa et al. J Environ Sci Eng. 2010; 52(3):199-204.
Bihar, India	1-5	20	Khandare et al. Calcif Tissue Int. 2005; 76(6):412-8.
Palamau, Jharkhand	Adults	47.4	Srikanth et al. Research report Fluoride. 2008; 41(3)206–211.
Assam	Adults	1.74	Chakraborti et al. Current Science. 2000;78 (12): 1421-1423.
Uttar Pradesh	All ages	14.2	Srivastava et al. International Journal of Oral & Maxillofacial Pathology. 2011:2(2):7-12.
Kareka, Shivpuri Madhya Pradesh	13-50	39.2	Saksena and Narwaria. Int j Environ Sci. 2012; 3(3).

Prevention and control of fluorosis:

Rajasthan and Gujarat in North India and Andhra in South India are worst affected. Punjab, Haryana, Madhya Pradesh and Maharashtra are moderately affected states in India, while the states Tamil Nadu, West Bengal, Uttar Pradesh, Bihar and Assam are mildly affected [23]. Since, the fluorosis is irreversible; its prevention is the appropriate, using various intervention measures. Fluoride poisoning can be prevented or minimized by using alternative water sources, by removing excessive fluoride from drinking water, and by improving the nutritional status of populations at risk. The simple interventions include provision of surface water, rainwater and consumption of Low-fluoride groundwater [24]. Other interventions are defluoridation of water through flocculation and adsorption. Similarly, health education and better nutrition are the some of the cost-effective intervention measures [24].

Authors have no conflicts of interests.

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Date of Submission: 21-06-2013
Date of Peer Review: 22-06-2013
Date of Acceptance: 28-06-2013
Date of Publication: 30-06-2013