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Dental fluorosis: A review

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Abstract
Dental fluorosis, a hypomineralization disorder of tooth enamel caused by excessive fluoride ingestion during enamel formation, manifests in various severities, from mild discoloration to severe structural damage. This review consolidates findings from studies across India to assess prevalence, causative factors, and mitigation strategies. The condition is influenced by fluoride levels in drinking water, dietary habits, and socioeconomic factors. For instance, in Manur block, Tamil Nadu, 28-33% of surveyed individuals exhibited dental fluorosis, with higher severity in regions with fluoride levels exceeding 2.0 mg/L. Similarly, in Karnataka's Koppal district, fluorosis prevalence among schoolchildren was 19%, correlating significantly with groundwater consumption.
Notably, fluoride's dual role as a caries prevention agent and a fluorosis contributor depends on its dose. Recommended exposure levels are 0.05-0.07 mg/kg body weight per day. However, overexposure due to environmental factors, such as high fluoride levels in bore well water (e.g., 0.6–19 mg/L in Maharashtra), amplifies risks. Effective interventions include public health measures like water defluoridation and dietary adjustments. This review underscores the need for region-specific strategies and continuous monitoring to balance fluoride's benefits against its risks.

Keywords: Dental fluorosis, fluoride exposure, enamel hypomineralization, groundwater, public health, India

Introduction
Dental fluorosis is a common disorder, characterized by hypomineralization of tooth enamel caused by ingestion of excessive fluoride during enamel formation.
It appears as a range of visual changes in enamel [4] causing degrees of intrinsic tooth discoloration, and, in some cases, physical damage to the teeth. The severity of the condition is dependent on the dose, duration, and age of the individual during the exposure [1]. The "very mild" (and most common) form of fluorosis, is characterized by small, opaque, "paper white" areas scattered irregularly over the tooth, covering less than 25% of the tooth surface. In the "mild" form of the disease, these mottled patches can involve up to half of the surface area of the teeth. When fluorosis is moderate, all of the surfaces of the teeth are mottled and teeth may be ground down and brown stains frequently "disfigure" the teeth. Severe fluorosis is characterized by brown discoloration and discrete or confluent pitting; brown stains are widespread and teeth often present a corroded-looking appearance. [1].
People with fluorosis are relatively resistant to dental caries (tooth decay caused by bacteria), although there may be cosmetic concern. In moderate to severe fluorosis, teeth are weakened and suffer permanent physical damage.
Subarayan bothi Gopalakrishna *et al*, worked on the prevalence of the fluorosis and identificed fluoride Endemic areas in Manur block of Thirunalveli district Tamil Nadu south India- 2012. He identified the fluoride endemic areas a total of 65 drinking water samples collected from 19 villages in Manur block of Thirunelveli district Tamil Nadu for fluoride analysis. He collected from particular villages identified by different symbol, in Manur block were classified in to three categories they are normal medium and high fluoride endemic area. The drinking water fluoride level lower than 0-1-2 above 2. 0 mg/l survey was conducted among people and school children of different age groups and gender residing in village of Manur block. The percentage of fluorosis was calculated from the number of people affected by fluorosis the area with total number of people surveyed. A total of 2. 879 school children aged group of 2570 schools examined for this study this survey including 19 schools and 19 villages located in Manur block of thirunalveli district. Flourides level in drinking water samples measured by using iron fluoride ion selective electrode using total ionic strength adjustment areas malapilliyarkulam are categorized as the as medium fluoride areas and other the percentage of fluorosis among the surveyed school children and villages in Manur block is 28% and 33% respectively. Nearly 26% of children and 58% of villagers residing in high fluoride areas are severly affected by dental fluorosis almost 41% and 33%

villagers in medium fluoride 29% of school children 31% of villagers in normal areas are having mild dental fluorosis symptoms This results indicate that the school children in the age group of 5 to 4 yrs and village people in the age group of 25-70 yrs are equally affected by dental fluorosis. The fluoride exposure dose level through drinking water decreases with increase in age from infants to adults.

Smita M. Nimbannavar *et al*., worked on the Prevalence of dental fluorosis among primary school children in Koppal district, Karnataka (2020). He studied on dental fluorosis by detected and graded using modified dens fluorosis index he collected 3150 questionnaires in the present study some were discarded owing to incomplete inaccurate and inconsistent entries there by leaving 3047 questionnaires for final dental fluorosis was almost similar among both male and female children fluorosis was significantly ($p<$ 0. 05) more in school children consuming mixed diet i. e 1771 (76. 30%) compared to the vegetarian counterparts and also the prevalence was significantly more among children's during groundwater 1571 (76. 48%) compared to those who consumed surface water severity of dental fluorosis with an average of 2 teeth being affected in each participant the previlance was calculated which came out to be 19% with 37 participants showing mild from 31 participants having moderate form and 27 having severe fluorosis.

John J Clarkson *et al*., worked on the role of fluoride in oral health promotion in trinity college, Dublin, Ireland (2000) Recommended amount of floride is expressed in milligrams per kilogram body weight. Estimates in the 1940s put the appropriate exposure at 1. 0 to 1. 5 milligrams per day which is the equivalent of 0. 05mg body weight per day. Current estimates recommends at 0. 05 to 0. 07 mg per kg body weight per day. The concentration of fluoride used in water fluoridation is based on a formula which related the annual average maximum daily air temperature in a particular region to water intake. This formula resulted in the recommendation that the concentration of fluoride in water in the US should be 0. 7 to 1. 2 ppm fluoride. In children aged 1 to 12 years of age this results in an estimated intake of 0. 05 mg of fluoride per kg body weight. This is important information when considering exposure to other sources of fluoride in fluoridated areas or in situations when foods are prepared with fluoridated water. The use of fluoride as a public health measures, such as through water or salt fluoridation, combined with the use of fluoride toothpastes, needs to be maintained into new regions.

C. S Chidankumar *et al.*, worked on the fluoride content of borewell water in Mysore city of Karnataka (2010) He investigated 20 borewell water sample from different location of Mysore city. Fluoride concentration in water sample was determined by standard methods APHA water standard prescribed by WHO fluoride concentration of borewell water varied from 0. 03 to 0. 35 mg / l which is below the limit of drinking water. More amount of fluoride in drinking water can cause fluorosis which affects the teeth and bones. He concluded that the borewell water of Mysore city is fit for drinking without any pretreatment of fluoride

Anandkumar Mishra *et al*, worked on the fluoride in drinking water: A challenge to public health High fluoride concentration in ground water resources has now become one of the major health related geo environmental issues in many countries of the world. Our country is also facing the same problem, where tue high fluoride concentration in ground water resources and the resulant disease fluorosis is widely distributed in nearly 150 districts of 15 states. In Madhya Pradesh during recent years, the problem of problem of fluoride has reached an alarming proportion. In this paper it is attempted to identify its sources, impact on human health and to develop a strategy fluorosis in the country. A large group of minerals containing minor fluorine is made-up of the fluorocarbonates, fluorosulphates, fluorophosphates, fluoroarsenates and fluorocolumbates. The fluoride contents in rocks range between 0. 1 and 1. 0 g/kg. The main primary fluoride containing minerals are fluorspar, cryolite and appetite. Besides rocks and soils, food items especially agricultural produce are heavily contaminated with fluoride, which enters into the human body through various food items. The available data indicates decreasing order of fluoride content in various food items as in cereals, followed by leaft vegetables, pulses, fish, meat and fruits. In the young age it is most harmed. However, fluoride toxicity and the biological response leading to ill effects depends on several other factors.

N. M. Kugali *et al*, worked on the pollution of drinking water due to fluoride and dental fluorosis at Hunagund taluk of Bagalkot district, Karnataka. (2010) water samples were collected in pet bottles of liter size and closed tightly. A total of 65 ground water samples were collected. Fluoride contents in all the samples have been determined. However, determinations of other ions and parameters have been carried out using standard methods (APH). The total number of people examined was 3000. Each persons teeth were carefully examined in natural light. The results were classified according to age and sverity. In the present study electrical conductivity values of the sample were found to be 590 to 5530 mhos/ cm. The pH value ranges from 7. 30 to 8. 93 and it is found to be well within the permitted limits prescribed for drinking water standards 6. 5 to 8. 5 WHO in 1970. The values of alkalinity ranged from 104 to 852 mg/L No research has been done in the Hunagundtaluk, so this study draws attention to the existence of problem in this area. Moreover, this is the first study which has been done to examine the extent of the condition in Hungundtaluk. It concluded that people consuming water more than 1. 5 ppm of fluoride are suffering from dental and skeletal fluorosis.

Mohammed Naji *et al*, worked on the fluoride concentration in groundwater of Arsikere taluk, Hassan district, Karnataka. He determined the fluoride content with 0. 6 to 1. 5 ppm as an essential constituent of drinking water, especially to prevent dental caries. The present study reveals at the concentration of fluoride ranges from 1. 4 mg/L to 2. 23 mg/L in post monsoon season in all the 20 sampling locations. Extensively worked on geochemical aspects of fluoride in groundwater of Behror tehsil of Alwar district in Rajasthan, and reported that the fluoride concentration varied from 0. 2 ppm to 5. 2 ppm and in this tehsil villagers were suffering from dental fluorosis, skeletal fluorosis and gut fluorosis. The study also revealed the maximum fluoride concentration of 2. 3 mg/L was present during monsoon season while minimum of 1. 1 mg /L in post-monsoon season. The maximum groundwater fluoride concentration in the study area was 2. 3 mg /L in monsoon season, while minimum of 1. 1 mg/ L post-monsoon season. The groundwater fluoride concentration in post-monsoon season was lower than the monsoon season due to dilution of fluoride concentration by rain water and increase in ground water.

Taranatha Mahantesh *et al*, worked on the prevalence of dental fluorosis and associated risk factors in Bagalkote district, Karnataka, India. The study was analysed risk factors for both prevalalence and severity of fluorosis separately. Total six risk factors, including fluoride concentration in drinking water, tea consumption, type of diet, nutritional status, breast feeding duration and water consumption per day were analysed to evaluate the connection with the prevalence and severity of fluorosis. In order to access the associations between risk factors and condition of fluorosis all289 children were divided into two groups namely no fluorosis and presence of fluorosis statistical analysis of two variable was observed positive associations between the prevalence of fluorosis and fluoride concentration in drinking water, frequency of tea consumption, nutritional status, and present water consumption. The risk factors and conditions of fluorosis showed that fluoride concentration in drinking water, type of diet, and nutritional status has significant associations.

Someshwar Golgire *et al*, worked on the estimation of fluoride level in drinking water and prevalence of dental fluorosis in Vairag village of Solapur district, Maharashtra, India. The fluoride concentration in the ground water of some villages in Maharashtra state varied from 0. 8 to 19 ppm causing dental fluorosis among people of villages. similar finding were obtained in the present study with fluoride concentration in drinking water samples ranging from 0. 64-7. 8 ppm causing dental fluorosis among the residents of the village. On the basis of clinical presentation, the dental fluorosis was observed with varying grades of discoloration of teeth ranging from chalky white flakes to brownish corroded stained with pitting appearance of teeth. He concluded that permanent teeth were affected more than primary study.

Sangita. V. Patel *et al*, worked on the magnitude of fluorosis and various invention to reduce fluorosis in Gujarat, India (2021) He studied the 6093 persons in dental fluorosis in high fluoride areas was 89. 3% while in normal fluoride areas condition was 39. 2% the skelealfluorosis was15. 6% with the prevalence of skeletal fluorosis as18. 61% in high fluoride areas 12. 19% in normal fluoride areas the fluorosis was seen higher in the age group of 12 years. He identified bith dental and skeletal fluorosis was high in Gujarat

Ravalika K N *et al*, worked on the socio demographic determinants of dental fluorosis in Mangalore (2019) His study was conducted in Mangalore among high school children aged 12-16 years a total of 500 students were examined for the present study. Study was belong to age group of 12-16 years the study population was formed by males which were 69. 5% (347) while females formed the remaining 30. 5% (153) socio economic states reported for the greater part of the study lower middle class 329 (65. 7%) which 169(33. 7%) were of upper middle and 2(0. 4%)were of upper lower class 304(60. 5%) participants families had less than equal to 4 family members it was observed that for affected by varying severity of dental fluorosis with an average of 2 teeth being affected in each participant the previlance was calculated which came out to be 19% with 37 participants showing mild from 31 participants having moderate form and 27 having severe form of dental fluorosis.

V. Vijay *et al*., worked on the prevalence of dental fluorosis among 12–15-year-old school-going children in Chengalpattu district, Tamil Nadu. August 2016. A cross-sectional survey was conducted among 12–15-year old school going children in Cheyyur taluk, Chengalpattu district Total of 1089 children in the selected eight schools of Cheyyur taluk were examined for dental fluorosis. Based on age, there were 217 children (19. 9%) in the 12-year-old age group, 282 children (25. 9%) in the 13-year-old age group, 364 children (33. 5%) in the 14-year-old age group, and 136 children (60. 2%) in 15-year-old age group. Based on gender, there were 491 (45. 1%) were boys and 598 (54. 9%) were girls. In the 1089 school children, the prevalence of dental fluorosis was present among 312 (28. 6%) students and 777 (71. 4%) of them were not affected by dental fluorosis When considering the severity of dental fluorosis, only 6 (0. 6%) and 56 (5. 1%) of the children were affected with the severe and moderate types of fluorosis, respectively, whereas 167 (15. 3%) of the children were affected by the mild form of fluorosis and 83 (7. 6%) were affected by a very mild form of fluorosis.

Lavanya Sirigala. *et al.*, Worked on prevalence of dental fluorosis and a cross-sectional study was done in schools in the study Kadapa district Andhra Pradesh. A total of 488 school children aged between 8 to 14 years were screened for fluorosis Oral examination of teeth was done to assess total of 48. 47% of girls and 40. 64% of boys were affected with dental fluorosis. A prevalence of 23. 06% mild, 22. 1% moderate, 5. 31% very mild, and 4. 55% severe dental fluorosis was observed in the dental fluorosis by the Deans's fluorosis Index. Fluoride levels in water in the study areas ranged between 1. 5 mg/l to 4. 2mg/l and there was a prevalence of 44. 05% dental fluorosis and 0% skeletal fluorosis in the school children.

A. Subramanian *et al*, worked on Dental Fluorosis and cross-sectional oral health survey in Kanyakumari District in 2009. 5000 individuals from rural areas (*Viz*) Azhagappapuram, Lakshmipuram, Punnarkulam, Bagavathypuram (South) and Nilapparai Villages. The Survey is restricted to a study area with 5000 population. Of which male population is 2262 (45. 24%) and female population is 2738(54. 76%). Of the 2262 Males, the number of dental fluorosis cases are 399 (17. 64%) and the rest 1863 (82. 36%) are normal subjects, where as in Females out of 2738(54. 76%), 456(16. 65%) have been effected for dental fluorosis positive cases, and the remaining 2282 (83. 35%) are normal subjects. The overall disease prevalence % in Male is 17. 64 and in Female it is 16. 65%.

A study conducted by Arjunan Isaac *et al*, in December 2009, among primary school children studying in 1st to 7th standard in the rural areas of Kaiwarahobli, Chikkaballapur district, Karnataka, on prevalence and severity of dental fluorosis and showed that of the 1, 544 children examined 42. 1% and 8. 4% had dental fluorosis respectively. Prevalence of very mild dental fluorosis and moderate fluorosis were high compared to other categories. Prevalence rates increased with the age and was more among girls (45.2%) as compared to boys (39. 1%). Of the 26 water samples analysed, 18 samples (69. 2%) revealed the fluoride content above the permissible limit.

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