The Dual Edge of Fluoride: Effects of Low Fluoride on Oral Health

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ABSTRACT

The concentration of fluoride in groundwater plays a pivotal role in public health, low levels of fluoride presenting distinct challenges. Jhunjhunu, a district in Rajasthan exhibits significant spatial variability in fluoride concentrations, ranging from deficient levels (>0.5-1.4ppm). Low fluoride levels are linked to increased susceptibility to dental caries, while high fluoride levels contribute to Dental fluorosis. The prevalence and severity of tooth decay & weaked enamel in Children in relation with different fluoride levels in drinking water of Jhunjhunu District, Rajasthan. Fluoride concentration in drinking was ranged from 0.3 ppm to 1.40 ppm in Jhunjhunu district, Rajasthan. Majority of children's affected with weaker teeth development were residents of low fluoride contaminated water. The prevalence of tooth decay and severity increased with unstable fluoride levels in drinking water .Hence the prevalence of dental fluorosis associated with high fluoride concentration & dental caries associated with low fluoride concentration in drinking water.

KEYWORD: Low fluoride level, dental health, tooth decay, fluoride supplement, jhunjhunu .

Introduction

Fluoride is essential for dental health, aiding in the remineralization of enamel and prevention of decay. Rajasthan known for its arid and semi-arid climate. Rajasthan heavily depends on groundwater as the primary source of drinking water. However, the region's unique geological composition leads to naturally low fluoride concentrations in groundwater, often exceeding the safe limits set by the World Health Organization (0.5-1.5 mg/L). Prolonged consumption of such fluoride-rich water has resulted in widespread cases of dental and skeletal fluorosis, severely impacting the health and socio-economic well-being of the affected communities.The prevalence of fluorosis in Rajasthan is among the highest in India, with nearly 18 out of 33 districts identified as endemic for fluoride-related health issues. Districts such as Nagaur, Ajmer, Jaipur, and Jhunjhunu, churu, sikar report alarming fluoride levels, causing significant health burdens, especially among children and rural populations. Fluorosis manifests in dental discoloration, enamel erosion, joint pain, and severe skeletal deformities, reducing the quality of life and economic productivity of the affected individuals. Low levels of fluoride toxicity during enamel formation may lead to enamel hypoplasia, a developmental defect characterized by reduced enamel thickness.highlighted that excessive fluoride exposure in early childhood can disrupt ameloblast activity, resulting in enamel defects that predispose individuals to dental caries.(Aoba, T., & Fejerskov, 2002).Mild fluorosis, caused by chronic exposure to low fluoride levels, often manifests as white spots on teeth. Hong et al. (2006) reported that although mild fluorosis is not harmful, it can negatively impact the aesthetic appearance of teeth, particularly in young individuals. (Kawasaki et al.,2008) found that low fluoride exposure during tooth development might impair dentin mineralization. Their research showed that fluoride interferes with the collagen matrix and mineral deposition, weakening the structural integrity of dentin. Fluoride accumulation in salivary glands may reduce salivary secretion, affecting oral health. (Oliveby et al. ,1989) demonstrated that chronic fluoride exposure alters salivary flow and buffering capacity, increasing vulnerability to caries and erosion. Low fluoride levels can inhibit bacterial metabolism.(Marquis et al.,1995) found that fluoride disrupts glycolysis in Streptococcus mutans , reducing acid production and caries risk. However, these changes may also alter the balance of beneficial oral microbiota.(Turner et al.,1996) observed that even low fluoride levels might influence alveolar bone dynamics. Chronic exposure was found to slightly alter osteoblast and osteoclast activity, potentially impacting periodontal health. (Chinoy et al.,1994) demonstrated that fluoride exposure induces oxidative stress in oral tissues by increasing free radical production. This oxidative imbalance can damage gingival and mucosal tissues, though the effects are subtle at low levels. (Barbier et al.,2010) reported that low fluoride exposure might irritate oral soft tissues, including the gums. While these effects are minimal, individuals with pre-existing conditions may experience increased inflammation.(Choi et al.,2012) linked fluoride exposure to subtle cognitive deficits that may influence oral hygiene behaviors. Reduced cognitive function may indirectly increase caries risk due to poor oral care practices. (Gopalakrishnan et al.,2013) showed that fluoride exposure might alter taste perception by affecting taste bud sensitivity. This alteration could influence dietary preferences, potentially increasing consumption of cariogenic foods.

This paper explores the prevalence, causes, and impacts of weaker teeth development in udaipurwati, pilani & chirawa block in jhunjhunu district , emphasizing the interplay of environmental, social, and infrastructural factors contributing to the crisis. Furthermore, it evaluates current mitigation strategies and highlights the urgent need for sustainable solutions, including improved water management practices, community awareness campaigns, and advancements in defluoridation technologies, to address this persistent public health challenge.

METHODS

Study area ; The present study was carried out in different villages of udaipurwati, pilani & chirawa block. A total of 68 villages were surveyed for fluoride level in water. Study area was divided into four categories with different fluoride level in drinking water on the basis of fluoride concentration in drinking water. These areas selected based on preliminary data from local water authorities, surveys, and existing groundwater quality reports.

Table.1 villages categorized on the basis of fluoride concentration in drinking water.

Category	Fluoride level in drinking water(ppm)
Category 1	Water sources having fluoride level <0.5
Category 2	Water sources have fluoride level ranging from 0.5-1.
Category 3	Water sources having fluoride level ranging from 1-1.05.
Category 4	Water sources having fluoride level ranging ≥2.

Research Design

A mixed-method approach will be employed, combining quantitative analysis of fluoride levels in water samples with qualitative interviews of residents and health officials. This design ensures a comprehensive understanding of the implications of low fluoride levels on public health.

Sampling Strategy

- Water Sampling: A stratified random sampling method will be used to collect groundwater samples from wells, hand pumps, and boreholes in regions with suspected low fluoride levels.
- Sample Size: Approximately 150 water samples will be collected to ensure statistical reliability. In some villages of udaipurwati, chirawa & ilani block of jhnujhunu district.Fluoride level was found to be less than one and in some villages it found between 1-2 ppm.

Table.2 fluoride distribution in Udaipurwati, Pilani & Chirawa block

Sr. No.	Name of Main Habitation	Fluoride(ppm)	Block	Sr. No.	Name of Main Habitation	Fluoride(ppm)	Block
1.	Bagoli	1.1	Udaipurwati	35.	Chirasan	0.3	Chirawa
2.	chak jodhpura	0.4	Udaipurwati	36.	Malupura	1.5	Chirawa
3.	Deepura	1.5	Udaipurwati	37.	keharpura kalan	1.2	Chirawa
4.	Bagora	1.2	Udaipurwati	38.	Gidania	1.4	Chirawa
5.	Chhapoli	0.8	Udaipurwati	39.	Sari	0.7	Chirawa
6.	Chanwara	0.6	Udaipurwati	40.	Shyampura	0.4	Chirawa
7.	jahaz	0.6	Udaipurwati	41.	Bajawa	2.2	Pilani
8.	Kakrana	0.6	Udaipurwati	42.	Bari	0.8	Chirawa
9.	guda	0.4	Udaipurwati	43.	khemu ki dhani	0.4	Chirawa
10.	guda dhahar	0.5	Udaipurwati	44.	bakhtawarpura	1	Chirawa
11.	Neori	0.91	Udaipurwati	45.	Bhukana	0.4	Chirawa
12.	Jagdishpura	0.3	Udaipurwati	46.	Lodipura	0.4	Chirawa
13.	Mandwara	0.72	Udaipurwati	47.	Shyopura	1.3	Chirawa

14.	Dhanawata	0.4	Udaipurwati	48.	Shekhpura	0.9	Chirawa
15.	Ponkh	0.4	Udaipurwati	49.	Bhompura	1.5	Chirawa
16.	Indrapura	0.4	Udaipurwati	50.	Badangarh	2.2	Pilani
17.	Kishorpura	0.3	Udaipurwati	51.	Gowli	1	Pilani
18.	Rajeevpura	1.5	Udaipurwati	52.	Chainpura	1.4	Pilani
19.	Kot	0.4	Udaipurwati	53.	Alampura	0.9	Pilani
20.	Katilpura	1.3	Udaipurwati	54.	bhawanipura	1	Pilani
21.	Sarai	1.2	Udaipurwati	55.	Jakhora	1.3	Pilani
22.	gudga gorji	1	Udaipurwati	56.	Manpara	1	Pilani
23.	Bamlas	0.4	Udaipurwati	57.	bhairoogarh	1.6	Pilani
24.	Sultana	0.4	Chirawa	58.	Devrod	0.9	Pilani
25.	Nari	1.4	Chirawa	59.	dhakkarwal	2.1	Pilani
26.	Budania	1.1	Chirawa	60.	Mandrella	0.4	Pilani
27.	Kithana	0.4	Chirawa	61.	bola ki dhani	3.5	Pilani
28.	Alipur	1.1	Chirawa	62.	Kaji	1.5	Pilani
29.	dheerawali dhani	1.3	Chirawa	63.	Hameenpur	1.5	Pilani
30.	mali gaon	1.4	Chirawa	64.	Dhandharia	0.4	Pilani
31.	Bhamarwasi	0.4	Chirawa	65.	Juharpura	0.8	Pilani
32.	Ardawata	0.6	Chirawa	66.	Laduna	1.5	Pilani
33.	Padampura	0.5	Chirawa	67.	ghumansar kalan	1.5	Pilani
34.	Chanana	0.4	Chirawa	68.	kulhariyon ka bas	1	Pilani

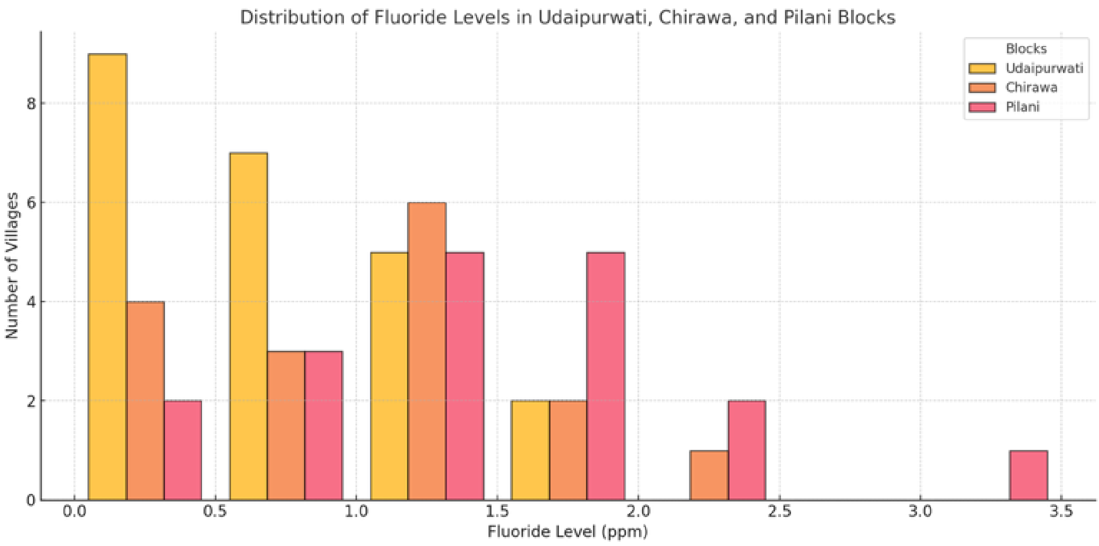
Data Collection Techniques

Fluoride Analysis: Collected water samples were analyzed using an ion-selective electrode (ISE) method to determine fluoride concentrations. Ion-selective electrodes (ISEs) measure the concentration of a specific ion in a solution by detecting the potential difference across a selective membrane. This potential is proportional to the ion activity (or concentration) in the solution, based on the principles of electrochemistry and the Nernst equation.

Health Surveys: Structured questionnaires will gather data on residents' dental health, water consumption patterns, and socioeconomic factors.

Data Analysis

Quantitative data was analyzed using statistical software to determine the mean, median, and range of fluoride levels. Qualitative survey responses will be coded and thematically analyzed to identify health impacts and community perceptions.



This histogram illustrates the distribution of fluoride level (in ppm) across villages in the udaipurwati, chirawa and pilani blocks. In udaipurwati block most of the villages have lower fluoride level between 0.0 to 0.5 ppm, Chirawa shows a balanced spread from 0.5-1.5 ppm while few villages of Pilani has highest fluoride concentration from 2.0-3.0 ppm indicating more severe fluoride contamination in specific areas.

RESULTS

Average fluoride levels in jhunjhunu were found to be 0.4-1.4 mg/l,below the optimal range for dental health.In children(5-12years) 57% had visible cavities and 28% reported enamel discoloration or sensitivity. In Adults (18+ years) 55% experienced tooth decay and 37% had advanced enamel erosion. Total 480 subjects are involved in the study was conducted in Udaipurwati , & Chirawa block or rural area of Jhunjhunu district of rajasthan. villages was selected on the basis of fluoride concentration in drinking water and divided into two Categories.Village level household survey was conducted to collect the information of water sources such as tap water &tube well.


Fig; 1-4 polymorphism & severity of teeth cavity and enamel erosion

The total 480 study was subject comprised of aged 5-12 year from male and female were surveyed found that 238 male & 160 female children with enamel Erosin & teeth cavity.Male children are more affected than female children.Factors contributing to this issue include groundwater Dependency,lack of awareness ,limited intervation.

Fluoride plays an important role in caries prevention however the low intake of fluoride for longer duration can have deketerious effects on teeth leading to cavities & enamel formation.it is also documented that even at optimal level and below optimum level of fluoride in drinking water, Preventive Strategies in Low-Fluoride Areas (Verma et al. 2022) this study was reviewed fluoride interventions in Rajasthan, including the use of fluoridated toothpaste and professional fluoride treatments. These measures were found to significantly reduce caries rates and improve enamel health in fluoride-deficient regions, fluoride levels and tooth longevity (Mangal et al, 2020) explored the long-term effects of low fluoride exposure on tooth retention in adults, Pareek et al. (2019) investigated public health initiatives addressing fluoride deficiency in Rajasthan. The study emphasized the need for fluoride supplementation programs, such as fluoridated salt distribution, to improve dental health outcomes. (sharma & mathue,2018) examined groundwater quality in rajasthan and its impact on dental health. There study confirmed that regions with fluoride levels below 0.5 mg/l experienced increased enamel erosin and sensitivity among residents, (meena et al. 2017) analyzed the economic impact of dental health issues in low-fluoride regions of Rajasthan. The study found that the cost of treating dental caries in these areas was substantially higher due to the absence of preventive fluoride measures, (kumar et al.2015) studied the oral health of rural populations in Rajasthan. Their findings indicated that individuals in low-fluoride areas exhibited a higher prevalence of dental caries, particularly among adults and the elderly, (Gupta et al.2012) reported a significant association between low fluoride levels in drinking water and enamel hypoplasia in children residing in Udaipur. The study also emphasized the role of nutrition in exacerbating the problem,(Singh et al.2011) focused on the prevalence of dental caries in schoolchildren from fluoride-deficient regions of Rajasthan. The study highlighted that 65% of children in these areas suffered from untreated dental decay, (Yadav et al.2009) analyzed fluoride concentrations in different districts of Rajasthan. They found that areas with low fluoride levels, such as Jhunjhunu and parts of Alwar, experienced increased dental issues compared to districts with optimal fluoride levels. The overall prevalence of dental health can be affected by a number of other factor such as nutrition status ,difference in kife style , climate ,altitude,individual susceptibility and biological response. In there study was an increase in the prevalence of dental health with an decrease in fluoride level in drinking water. However,due to the many limitation in the study more research with larger sample sizes is needed to arrive at any definite conclusion.

CONCLUSION

Our data showed that Fluoride is a crucial element in maintaining oral health, primarily through its ability to strengthen enamel, enhance remineralization, and protect teeth from decay. However, in areas like Jhunjhunu district, Rajasthan, where fluoride levels in drinking water are below the optimal range, the impact of this deficiency on dental health is significant. The district's reliance on groundwater with naturally low fluoride content has led to widespread oral health issues, affecting various age groups but particularly children and the rural population.Studies and surveys in Udaipurwati &chirawa block in Jhunjhunu have consistently shown an increased prevalence of dental caries, enamel erosion, and tooth sensitivity. Children exposed to low fluoride levels during enamel formation often experience weaker and less mineralized enamel, making their teeth more susceptible to cavities. Adults and the elderly, on the other hand, face progressive enamel wear, leading to exposure of the underlying dentin, increased tooth sensitivity, and higher rates of tooth decay. These issues not only compromise oral health but also contribute to poor quality of life and increased healthcare costs for the affected population.

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