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Assessment of Fluoride Level in Groundwater and Prevalence of Dental Fluorosis in Didwana Block of Nagaur District, Central Rajasthan, India

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Abstract

Background: In India, for the high concentration of fluoride in groundwater, people are at risk of dental fluorosis. The problem is common in various states of India. The condition in Rajasthan is worse where all districts have such a problem.

Objective: To study the fluoride concentration in groundwater and prevalence of dental fluorosis in Didwana block of Nagaur district, Central Rajasthan, India.

Methods: The fluoride concentration in water of 54 villages was measured electrochemically, using fluoride ion selective electrode. Dental fluorosis was assessed in 1136 people residing in study area by Dean's classification for dental fluorosis.

Results: The fluoride concentration in groundwater in studied sites ranged from 0.5 to 8.5 mg/L. The concentration of fluoride was more than the maximum permissible limit set by WHO and Bureau of Indian Standards (1 mg/L) in 48 groundwater sources. Of 1136 people studied, 788 (69.4%; 95% CI: 66.7%–72.1%) had dental fluorosis—252 had mild and 74 had severe dental fluorosis.

Conclusion: High level of fluoride in drinking water of Didwana block of Nagaur district, Central Rajasthan, India, causes dental fluorosis in most people in the region and is an important health problem that needs prompt attention.

Keywords: Groundwater; Fluorides; Fluorosis, dental; Prevention and control; India

Introduction

It is well established that India has two acute public-health problems induced by utilization of groundwater as a source of drinking water having excess

fluoride and arsenic. Fluoride ranks 17th in abundance of elements in the earth's crust, representing 0.06%–0.09% of the earth's crust.¹ Fluoride is one of the important life elements. It is essential for normal mineralization of bones and for-

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mation of dental enamel.² When fluoride is taken more than the permissible limit, it becomes toxic and would cause various metabolic disturbances in animals and human being including dental and skeletal fluorosis.³⁻⁶

Generally, most groundwater sources have higher fluoride concentrations than surface water. As groundwater percolates through the weathered rock in the aquifers, it dissolves fluoride bearing minerals, hence releasing fluoride into solution.⁷ The main source of fluoride in groundwater is basically from the rocks minerals. In Indian continent, the highest concentration of fluoride in groundwater is associated with igneous and metamorphic rocks and about 62 million people are at risk of developing fluorosis from drinking water with high fluoride concentration. The problems are most pronounced in Andhra Pradesh, Bihar, Gujarat, Madhya Pradesh, Punjab, Rajasthan, Tamil Nadu, and Uttar Pradesh.^{4,5,8-16}

Rajasthan is the largest state of India (342 239 km² wide) with a relatively low population density of 165 people/km². According to physiography divisions, the northern and western part of the state is under The Great Plain of North India while southern and middle as well as eastern parts are classified under the Peninsular Plateau.¹⁷ Rajasthan is unique, as all its 32 districts have had variable fluoride contamination in groundwater. Most of the fluoride-related groundwater studies in Rajasthan have been focused on the western and southern parts of the state, which are conventionally described as "high fluoride" areas.¹⁸ Review of the literature showed that no studies have so far been undertaken in the study area with regard to fluoride and fluorosis. Therefore, this study was to conducted to measure the fluoride concentration in drinking water (underground water) and to assess the prevalence of dental fluorosis in Didwana

Tehsil, Central Rajasthan, India.

Materials and Methods

Study area

Didwana Tehsil of Nagaur district is located at latitude 27° 23' 58.10" N and longitude 74° 34' 33.39" E in central Rajasthan. The total area of Didwana is 1647 km² of which 1632 km² is rural area and the remaining 15 km² is urban. Didwana have 172 villages. Didwana Tehsil is situated on the eastern part of Nagaur district. Its average elevation is about 300 m from sea level—ranging from below 250 m in the South to 640 m in the North. Its geographical spread is a good combination of plain, hills, sand mounds and such as it is a part of the great Indian Thar Desert.¹⁷

Water sample collection

Out of 172 villages of Didwana block, 54 villages were selected using a proportional weighted sampling technique. Two-hundred and ten groundwater samples from these villages were collected in pre-cleaned polythene bottles with necessary

For more information on fluoride concentration in groundwater in rural areas of Razavi Khorasan province, northeastern Iran see www.thejjoem.com/ijournal/index.php/ijournal/article/view/167

TAKE-HOME MESSAGE

- Fluoride is one of the important life elements. It is essential for normal mineralization of bones and formation of dental enamel.
- When fluoride is taken more than the permissible limit, it becomes toxic and would cause various metabolic disturbances in animals and human being including dental and skeletal fluorosis.
- The prevalence of dental fluorosis increases with fluoride concentration in drinking water.
- High level of fluoride in drinking water of Didwana block of Nagaur district, Central Rajasthan, India, causes dental fluorosis in most people in the region and is an important health problem that needs prompt attention.

Table 1: Dean's (1942) classification for dental fluorosis

Normal	The enamel presents translucent, semi-vitriform type of structure. The surface is smooth, glossy and usually pale creamy white color.
Questionable	Slight aberrations in translucency, ranging from a few white flecks to occasional white spots.
Very Mild	Small, opaque paper-white areas seen, scattering irregularly over the labial and buccal tooth surfaces. Involves <25% of tooth surface
Mild	The white opaque areas involve at least half of the tooth surface; faint brown stains are sometimes apparent.
Moderately	Generally all tooth surfaces are involved and minute pitting is often present on the labial and buccal surfaces. Brown stains are frequently a disfiguring complication.
Severe	Severe hypoplasia affect the form of the teeth, stains are widespread, and vary in intensity from deep brown to black.

precautions.¹⁹ The samples were collected, during the year 2012, from manually operated hand pumps either privately owned or established by the government of Rajasthan.

Methodology

The fluoride concentration in water was measured electrochemically, using a fluoride ion selective electrode.²⁰ This method can be used for the measurement of fluoride in drinking water in the concentration range of 0.01–1000 mg/L. The electrode used was an Orion fluoride electrode coupled to an Orion electrometer. Standards fluoride solutions (0.1–10 mg/L) were prepared from a stock solution (100 mg/L) of sodium fluoride. As per experimental requirement, 1 mL of total ionic strength adjusting buffer grade III (TISAB III) was added to 10 mL of

sample. The ion meter was calibrated for a slope of 59.2 ± 2 . TISAB solution composed of 385.4 g ammonium acetate, 17.3 g cyclohexylene diamine tetra-acetic acid, and 234 mL concentrate hydrochloric acid per liter. All the experiments were carried out in triplicate, and the results were found reproducible with $\pm 2\%$ error. The measured fluoride concentrations ≤ 1 , 1.01–1.5, 1.51–3.0, 3.01–5.0, and > 5.0 mg/L were then categorized into “category I” to “category V,” respectively.

Survey for the dental fluorosis

Only those villages where the mean fluoride concentration was > 1.0 mg/L (48 villages) were selected for the dental fluorosis survey. Appropriate precaution was taken in the diagnosis of dental fluorosis since it is often mistaken with the stains imposed on teeth by chewing tobacco and smoking. The characteristic of different grades of dental fluorosis is grouped as described earlier.²¹ Grading of dental fluorosis is presented in Table 1.

Result

Fluoride concentration in 210 groundwater samples of 54 villages in Didwana Tehsil was measured. The concentration in the Tehsil ranged from 0.5 to 8.5 mg/L. The minimum mean fluoride concentration of 0.9 mg/L was recorded from village Singrawat Kalan, and the maximum value 5.8 mg/L was recorded from village Didwana. Four (7.4%) villages fell in “category I,” *ie*, mean fluoride concentration of ≤ 1.0 mg/L—the maximum desirable limit of standards for drinking water recommended by the Bureau of Indian Standard.²²

Out of 54 studied villages of Didwana Tehsil, two (4%) villages had mean fluoride concentration between 1.01–1.5 mg/L (category II)—the maximum permissible limit of fluoride in standard for

drinking water.²² The population of these habitations have a fluoride intake of >4 mg/day through drinking water and are thus at risk of developing first and second degree dental fluorosis. Twenty-six (48%) villages had groundwater with mean fluoride concentration from 1.51–3.0 mg/L—a level above the maximum permissible limit as recommended by BIS.²² At this concentration, the teeth lose their shiny appearance; chalky black, gray, or white patches may develop and cause “mottled enamel.”²¹ In 19 (35%) villages, the mean fluoride concentration in groundwater was from 3.0 to 5.0 mg/L (category IV). The daily fluoride intake by these people is very high that would cause dental as well as skeletal fluorosis. Three (6%) villages fell in category V, where the mean fluoride concentration was >5.0 mg/L; this level of fluoride may produce all types of fluorosis among inhabitants. In advanced stages of the disease, the affected people may develop calcification in ligaments and experience bony pains. It has also been reported that such people may suffer from stiffness in joints. At this concentration, the vertebrae partially fuse together crippling the patient—a situation known as “crippling skeletal fluorosis.”

Dental fluorosis

Figure 1 shows the prevalence of dental fluorosis in 48 villages having mean fluoride concentration >1.0 mg/L is shown in Figure 1. Of 1136 people studied, 788 (69.4%; 95% CI: 66.7%–72.1%) had dental fluorosis. In 18 villages the prevalence was >75%; in only five villages the prevalence was <25%. As expected in villages with higher fluoride concentration in groundwater, the prevalence of dental fluorosis was higher ($r = 0.78$, $p < 0.001$, Fig 1). Figure 2 represents the prevalence of dental fluorosis in different age groups. Below the age of 36, there was a small difference in the prevalence of dental fluoro-

sis in males and females. However, after age 36, the prevalence in males was higher than females (Fig 2).

Discussion

Our findings corroborate other recent investigations indicating that the prevalence of dental fluorosis increases with fluoride concentration in drinking water.^{18,23,24} This suggests that the prevalence of dental fluorosis can vary widely from region to region following the concentration of fluoride in drinking water. However, besides water fluoride concentration and duration of exposure, other factors such as dissolved salts in drinking water and nutritional habits would also affect the prevalence of dental fluorosis.

The only remedy is prevention by keeping fluoride intake within the safe limits. Fluoride poisoning can be prevented or minimized by using alternative water sources, removing excess fluoride, and improving the nutritional status of the population at risk. Clinical data indicate that adequate calcium intake is clearly associated with a reduced risk of dental fluorosis.^{25,26} Vitamin C may also act as a safeguard against the risk. Therefore, measures to improve the nutritional status of an affected population, particularly in children, appear to be an effective supplement for an antidote against fluorosis.

In studied villages, fluorosis is caused mainly by excess intake of fluoride in drinking water. We observed a significant dose-response relationships between water fluoride level and prevalence of dental fluorosis (Fig 1) so that 61% of the variation in the observed prevalence rates of dental fluorosis could be explained by variation in the fluoride level. These are consistent with findings of other studies.²⁷

Several researchers reported variable prevalence rates of dental fluorosis in people, however, their common find-

For more information on fluoride concentration in groundwater and dental fluorosis in permanent teeth of school children in rural areas of Haryana state, India see www.theijoom.com/ijoom/index.php/ijoom/article/view/196

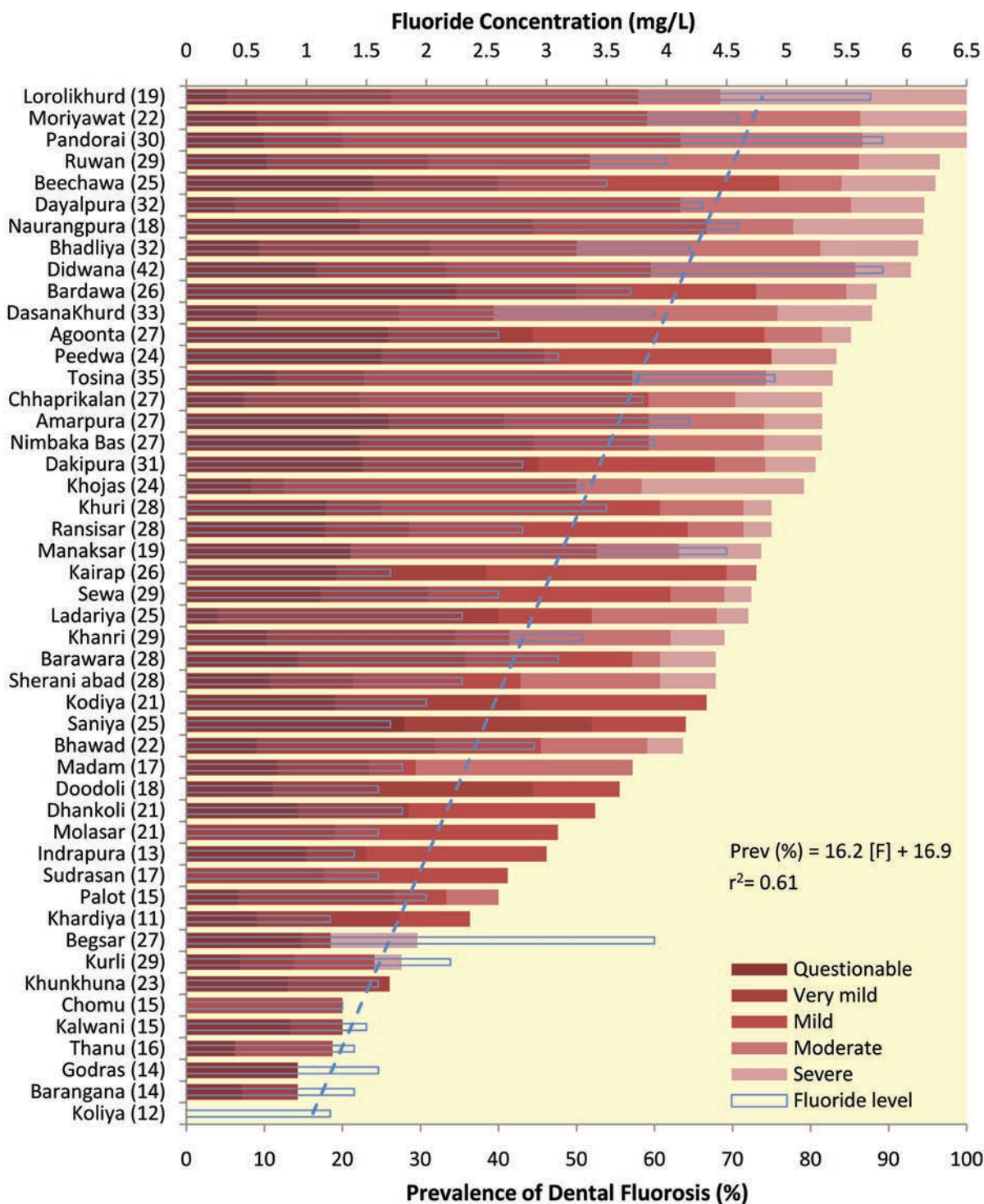


Figure 1: Prevalence of dental fluorosis in 48 villages where fluoride level in the water was >1 mg/dL (the red stacked bars) stratified by severity according to Dean's classification (Table 1). The number in parenthesis following each village represents the number of people studied in that village. The blue bars depict fluoride concentration in each village (use the top axis to read the values). The dashed blue line is the linear regression line with prevalence of dental fluorosis as dependent variable and fluoride concentration as independent variable.

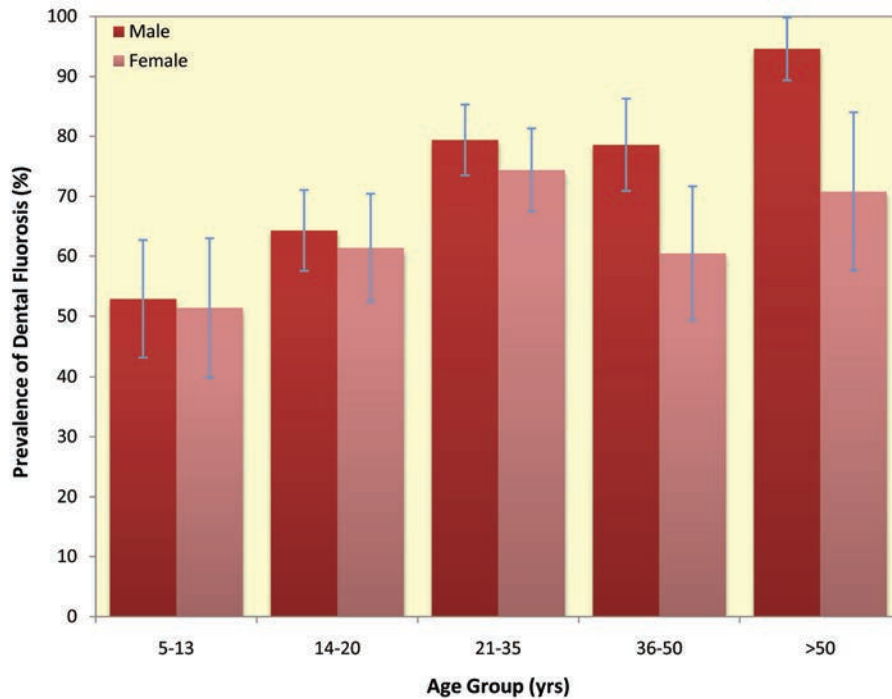


Figure 2: Prevalence of dental fluorosis in different age groups stratified by gender. Error bars represent 95% CI.

ings about dental fluorosis was that a) the prevalence is higher in areas with higher fluoride concentration, b) the rate decreased with increasing age, and c) it is higher in males than females. We found that the prevalence of dental fluorosis was not significantly different between males and females aged <36 years. After age 36, however, the prevalence was higher in men than women (Fig 2). This difference may be due to migrating females from other villages after marriage.

In conclusion, high level of fluoride in drinking water of Didwana block of Nagaur district, Central Rajasthan, India, causes dental fluorosis in most people in the region and is an important health problem that needs prompt attention. Because fluoride level in drinking water could explain only 61% of variation in the prevalence of dental fluorosis, further studies to find other possible contributing factors are needed.

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Conflicts of Interest: None declared.

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