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Assessment of fluoride content and microbial quality of potable water near rural government primary schools of Doni and Kalkeri villages of Mundargi taluk Gadag district Karnataka in an Indian context

Sudha kumbar[1], Dr. Vidya Kittali[2], Shivaraj Kumbar[3], Sangeetha VJ[4], Savitha V Jammanakatti[1]
[1] Research Scholar, Department of Studies and Research in Food Processing and Nutrition, Karnataka State Akkamahadevi Women University, Vijayapura, Karnataka, India
[2] Assistant Professor, Department of Home Science, Food Science and Nutrition, Maharani Science College for women Mysore, Karnataka, India
[3] Associate Professor, Department of Community Health Nursing, GIMS Government College of Nursing, Gadag, Karnataka, India
[4] Research Scholar, Department of food chemistry, ICMR - National Institute of Nutrition, Hyderabad, Telangana, India

Abstract
Fluorosis is a significant public health concern resulting from prolonged consumption of fluoride-contaminated drinking water. Excessive fluoride intake can lead to dental, skeletal, and non-skeletal fluorosis. In India, approximately 62 million people, including 6 million children, are estimated to suffer from fluoride-related health issues. The lack of awareness regarding drinking water quality further exacerbates the problem. Therefore, early detection of fluoride toxicity and implementation of preventive measures are crucial. Aim of this study was to assess the fluoride content in drinking water sources located near rural Government Primary Schools in Doni and Kalkeri villages of Mundargi Taluk, Gadag District, Karnataka, India. Main objective of this study was to determine the fluoride concentration in potable water sources near selected rural schools in Doni and Kalkeri villages. The study involved collecting potable water samples from various sources in Doni and Kalkeri villages. Fluoride estimation was performed using standard procedures in a fluoride testing laboratory, and microbial quality was assessed in a microbiology laboratory. A total of 20 water samples were analyzed for fluoride content. Among them, 18 samples contained fluoride concentrations exceeding 1 ppm, rendering them unfit for drinking according to WHO standards, while only 2 samples met the safety limits. Microbial analysis revealed that only 2 of the 20 water sources were suitable for drinking, whereas the remaining sources were contaminated. Notably, Kalkeri village exhibited higher fluoride levels compared to Doni village. Out of the 20 tested samples, only 2 were found safe for human consumption. The high fluoride and microbial contamination levels in most water sources indicate an urgent need for water purification measures such as chlorination and filtration to ensure safe drinking water in these rural areas.

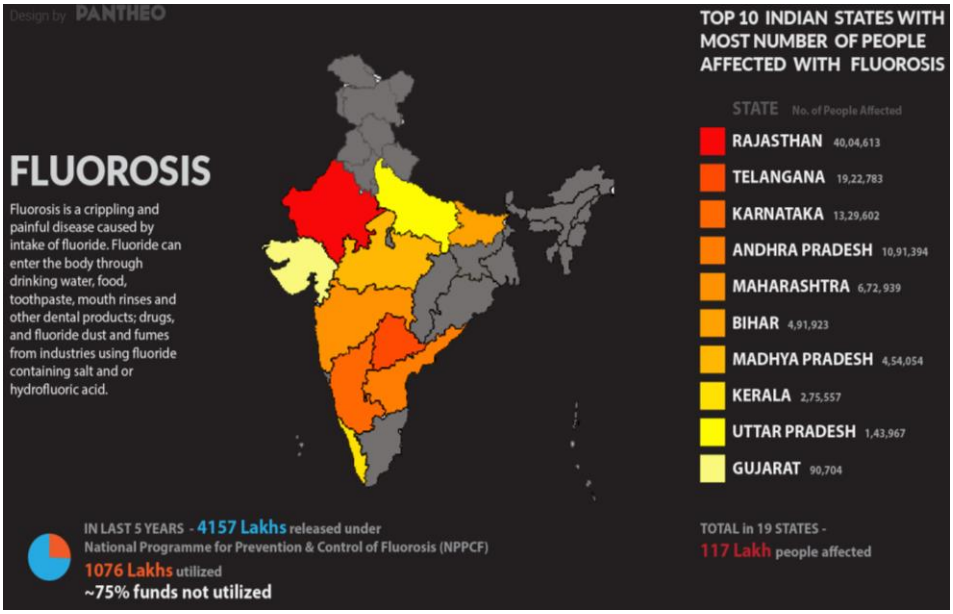
Keywords: Fluoride, chlorinated, portable water, filtered

Introduction

India lies within the global "fluoride belt," a region characterized by naturally high fluoride concentrations in rocks and soils. In such areas, the leaching of fluoride from geological formations into groundwater leads to elevated fluoride levels. The concentration of fluoride in water is influenced by several environmental factors, including the solubility of fluoride-bearing minerals, the presence of other ions, soil acidity, and the availability of ground water. All of which contribute to regional variations in fluoride content [5].

Drinking water is the primary dietary source of fluoride for humans. Additionally, fluoride may enter the diet through foods such as saltwater fish, sorghum, finger millet, and crops cultivated in soil irrigated with fluoride-rich water. Although fluoride is an essential micronutrient required for the development and maintenance of bones and teeth where approximately 99% of the body's fluoride is stored in calcified tissues, it is beneficial only within optimal limits. Adequate intake helps prevent dental caries by promoting the formation of hydroxyl apatite with calcium; however, prolonged exposure to high fluoride concentrations can lead to dental fluorosis, skeletal fluorosis, and a reduction in intelligence quotient (IQ) [8].

In India, nearly 72% of the population resides in rural areas without access to piped drinking water and primarily depends on groundwater sources such as wells. Consequently, fluoride ingestion through contaminated groundwater poses a major health risk. The Bureau of Indian Standards (BIS) has established 1 ppm as the maximum permissible limit for fluoride in drinking water. Despite this guideline, several regions across India report fluoride concentrations ranging from 0.5 ppm to as high as 29 ppm, resulting in widespread endemic fluorosis [7].

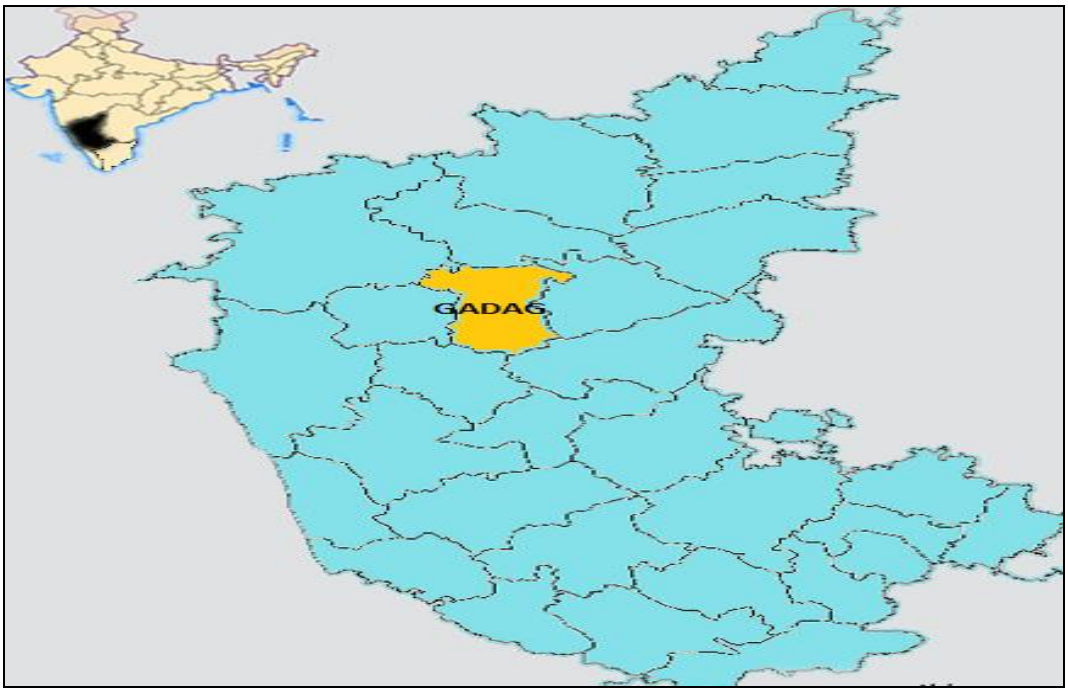


Source: Ministry of health & family welfare data as on 1st April 2018.

Fig 1: Top 10 indian states affected with Fluorosis.

In India, an estimated 62 million people, including approximately 6 million children, suffer from serious health problems caused by the consumption of fluoride-contaminated water. Endemic fluorosis has been reported in nearly fifteen states across the country. In recent years, the prevalence of both dental and skeletal fluorosis has shown an upward trend due to several contributing factors, including [3]

- Rapid population growth leading to increased demand for water resources;
- Indiscriminate drilling of tube wells in fluoride-endemic regions as a result of water scarcity, which in turn increases the reliance on fluoride-rich groundwater;
- Lack of public awareness regarding the importance of safe drinking water and regular water quality monitoring (RGNDWM, New Delhi).



In Karnataka, the Gadag district has been identified as a naturally fluoridated region based on surveys conducted by the Rajiv Gandhi National Drinking Water Mission (RGNDWM), New Delhi, and the Government of India. The rural population in this district primarily depends on groundwater for both domestic and agricultural needs. Due to its semi-arid nature and frequent water shortages, the number of bore wells has increased significantly over the years, resulting in excessive groundwater extraction. Consequently, residents in these areas face an elevated risk of developing fluorosis. Since populations residing in high-fluoride regions are prone to both dental and skeletal fluorosis, the early detection of fluoride toxicity is of great importance for effective prevention and control [1].

Need for the Study

Prevention

Fluorosis is recognized as a major public health problem in more than 24 countries worldwide. It primarily results from prolonged exposure to high levels of fluoride, mainly through drinking water and, to a lesser extent, through fluoride-containing food items. A continuous fluoride concentration of 1.5 ppm or higher in drinking water is considered hazardous to human health, particularly affecting bones and teeth. Dental fluorosis can be effectively prevented by reducing fluoride intake to levels below the tolerable upper limit. The prevalence of fluorosis in affected populations can be minimized by implementing defluoridation techniques for drinking water. However, additional sources of fluoride such as fluoridated toothpaste and certain dietary components must also be considered. It is important to note that defluoridation can prevent further exposure but cannot reverse fluorosis once damage has occurred during the period of tooth enamel formation. Therefore, the present study was undertaken to assess the fluoride content in drinking water sources of Kalkeri and Doni villages in Mundargi Taluk, Gadag District, Karnataka, to evaluate the extent of fluoride contamination and its potential health implications in a rural Indian context. The aim of the study is to assess the fluoride content in drinking water sources near rural government primary schools in Doni and Kalkeri villages, Mundargi Taluk, Gadag District, Karnataka, India.

Objectives

1. To determine the fluoride concentration in potable water sources near rural government primary schools in Doni and Kalkeri villages.
2. To evaluate the water quality in relation to the permissible fluoride limits set by the Bureau of Indian Standards (BIS).
3. To evaluation of microbial contamination levels in potable water sources near rural government primary schools in Doni and Kalkeri villages.
4. To provide baseline data that may inform preventive and mitigation measures for fluorosis in the study area.

Methodology

1. Study area

The study region Mundaragi taluk is situated at 15.207°N 75.884°E. Mundaragi is a Taluk and a municipality in Gadag district, Karnataka state of India.

Mundargi Taluk is situated in Gadag District, Karnataka, and lies adjacent to two regional headquarters: it is approximately 35 km from Gadag and 49 km from Koppal, and about 98 km from Gajendragad. Most villages in this region rely primarily on groundwater sources for drinking purposes. For this study, two villages—Doni and Kalkeri—were selected from Mundargi Taluk to assess the fluoride content in their drinking water sources. These villages represent typical rural communities in the district, where groundwater serves as the main source of potable water.

2. Water Sample Collection

A total of 20 potable water samples were collected from the study area during the year 2019: 10 samples from Doni village and 10 samples from Kalkeri village. All samples were collected in pre-cleaned polythene bottles while following standard precautions to avoid contamination.

3. Fluoride Analysis

Fluoride concentration in the water samples was measured electrochemically using a fluoride ion-selective electrode (Orion fluoride electrode coupled to an Orion electrometer). This method allows the measurement of fluoride in drinking water within a concentration range of 0.01–1000 mg/l.

Procedure

- Standard fluoride solutions (0.1–10 mg/L) were prepared from a stock solution of 100 mg/l sodium fluoride.
- For each sample, 1 ml of Total Ionic Strength Adjusting Buffer (TISAB III) was added to 10 ml of water.
- The ion meter was calibrated to a slope of 59.2 ± 2.
- The TISAB III solution consisted of 385.4 g ammonium acetate, 17.3g cyclohexylene diamine tetra-acetic acid, and 234 ml concentrated hydrochloric acid per liter.
- All measurements were performed in triplicate, with reproducibility within ±2% error.

The measured fluoride concentrations were categorized as follows

1. ≤1 mg/L
2. 1.01–1.5 mg/L
3. 1.51–3.0 mg/L
4. 3.01–5.0 mg/L
5. 5.0 mg/L

4. Microbial contamination level Analysis

The membrane filtration technique was employed to assess microbial contamination, specifically targeting *E. coli*. In this method

- Water samples were filtered through a membrane filter.
- The filter was then placed on a selective culture medium for *E. coli*.
- Bacteria retained on the membrane surface grew into visible colonies, indicating microbial contamination.

Results and Discussion

1. Assessment of fluoride content of water samples

Results were statistically analysed. The research results show that

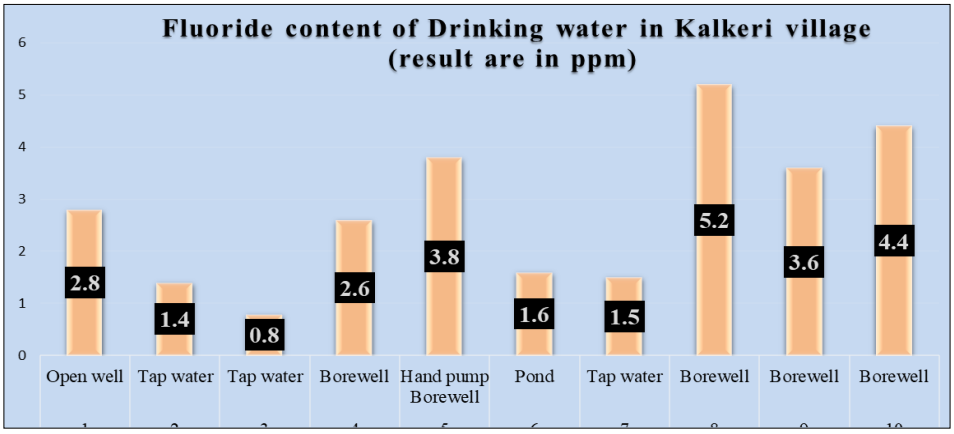


Fig. 2: 10 Water samples fluoride content of Kalkeri village

In Kalkeri village, a total of 10 water samples were collected and tested for fluoride content. Among these, 9 samples exceeded 1 ppm, making them unfit for drinking according to WHO standards. Of these 9 samples, 5 samples contained fluoride levels above 2 ppm, including one borewell sample with a fluoride concentration of 5.2 ppm. Only 1 water sample, a filtered tap water sample, was found to be safe for drinking, with a fluoride level below 1 ppm.

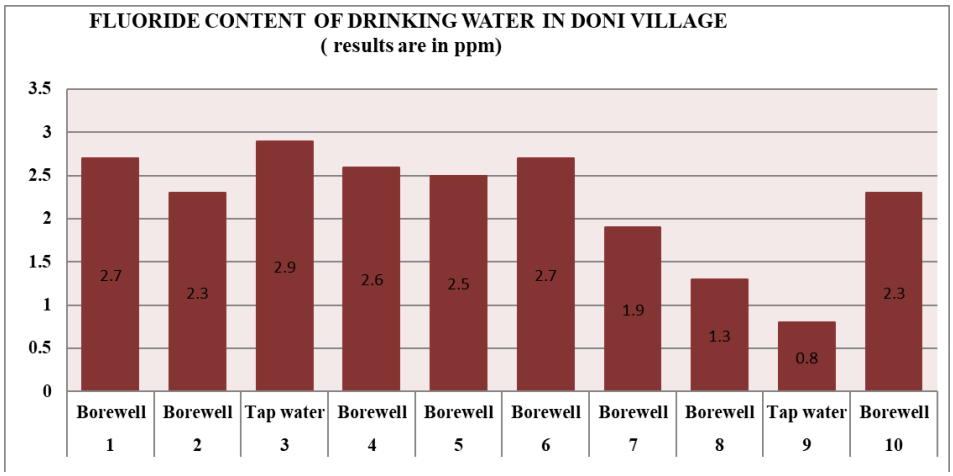


Fig 3: 10 Water samples fluoride content of Doni village

In Doni village, a total of 10 water samples were collected and tested for fluoride content. Among these, 9 samples exceeded 1 ppm, making them unfit for drinking according to WHO standards. Of these 9 samples, 7 samples had fluoride levels above 2 ppm, including one tap water sample with a fluoride concentration of 2.9 ppm. Only 1 water sample, a filtered tap water sample, was found to be safe for drinking, with a fluoride level below 1 ppm.

A total of 20 water samples were tested for fluoride content in Kalkeri and Doni villages. Among these, 18 samples exceeded 1 ppm, making them unfit for drinking according to WHO standards. Only 2 samples had fluoride levels below 1 ppm, and were therefore considered safe for drinking.

2. Microbial contamination level Analysis

- All 20 samples were tested for *E. coli* contamination.
- 18 samples were contaminated, while only 2 sources were microbiologically safe for drinking.

The same 20 water samples were also tested for *E. coli* contamination. Among them, only 2 water sources were found to be fit for drinking, while the remaining 18 sources were microbiologically unsafe. All unfit water sources should be chlorinated and filtered before consumption.

Implications

The results indicate an urgent need for defluoridation, chlorination, and filtration of water sources in both Kalkeri and Doni villages. Community awareness programs on safe water practices and regular monitoring of fluoride and microbial content are essential to prevent fluorosis and waterborne diseases.

Discussion

The results indicate a widespread occurrence of unsafe fluoride levels in both Kalkeri and Doni villages, posing a significant risk of dental and skeletal fluorosis. Elevated fluoride concentrations, reaching up to 5.2 ppm, emphasize the need for urgent intervention. Concurrent microbial contamination further exacerbates the risk, highlighting the dual threat of chemical and microbial hazards. The safety of filtered tap water samples demonstrates the effectiveness of water treatment measures such as filtration. These findings underline the necessity for defluoridation, chlorination, and regular water quality monitoring. Additionally, implementing community awareness programs on safe water practices is essential to prevent fluorosis and waterborne diseases in the region.

Conclusion

The study revealed that most drinking water sources in Kalkeri and Doni villages exceed the safe fluoride limit of 1 ppm, with concentrations reaching up to 5.2 ppm, placing residents at high risk of dental and skeletal fluorosis. Concurrently, 18 out of 20 water sources were contaminated with *E. coli*, indicating significant microbial hazards. Filtered tap water was found safe, demonstrating the effectiveness of simple treatment methods. These findings underscore the urgent need for defluoridation, chlorination, regular water quality monitoring, and community awareness programs to ensure safe drinking water and prevent fluorosis and waterborne diseases.

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