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Assessment of Microbial Quality and Fluoride Content of Potable Water in Rural Government Primary Schools of Mundargi Taluk, Karnataka, India

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Safe drinking water is essential for public health; however, rural communities often face challenges due to chemical and microbial contamination of potable water. Fluoride contamination is a major public health concern because prolonged consumption of excess fluoride can cause dental and skeletal fluorosis, while microbial contamination increases the risk of waterborne diseases. The present study aimed to assess the microbial quality and fluoride content of potable water from Government Primary Schools in Doni and Kalkeri villages of Mundargi Taluk, Karnataka, India. A total of 20 potable water samples were collected from different drinking water sources located near the selected schools. Fluoride concentration was determined using standard laboratory procedures, and microbial quality was evaluated by microbiological analysis following standard methods. Among the 20 water samples analyzed, 18 contained fluoride concentrations above the World Health Organization (WHO) permissible limit of 1.0 mg/L, while only two samples met the recommended standard. Microbiological examination further revealed that only two water samples were free from microbial contamination and considered suitable for drinking, whereas the remaining samples showed microbial contamination, indicating poor water quality. Kalkeri village recorded comparatively higher fluoride concentrations than Doni village. The findings demonstrate that most potable water sources in the study area are unsuitable for human consumption because of elevated fluoride levels and microbial contamination. Regular monitoring of drinking water quality, together with appropriate water treatment measures such as filtration, chlorination, and community awareness programs, is essential to ensure safe drinking water and to reduce the risk of fluorosis and waterborne diseases in rural communities.

Introduction

India's location within the global "fluoride belt" presents a significant public health challenge, as naturally high fluoride concentrations in rocks and soils frequently leach into groundwater. This geological phenomenon, combined with semi-arid climatic conditions and increasing groundwater extraction, has contributed to widespread fluoride contamination across numerous states.

In Karnataka, groundwater quality assessments have revealed that fluoride levels exceed permissible limits in several districts, including Gadag, with concentrations reaching up to 6.44 mg/L in some wells. The over-exploitation of groundwater resources in areas categorized as over-exploited, critical, and semi-critical has been identified as a major factor contributing to groundwater fluoride contamination (1, 6).

Rural populations in these regions are particularly vulnerable, especially school-aged children who are susceptible to dental and skeletal fluorosis during critical stages of growth and development. Previous studies conducted in Karnataka have reported a high prevalence of fluorosis among school children living in fluoride-endemic areas, highlighting the importance of routine monitoring of drinking water quality in educational institutions (2, 6).

Although fluoride is an essential trace element required for the normal development and maintenance of bones and teeth, prolonged consumption of drinking water containing fluoride concentrations above the recommended limit can result in dental fluorosis, skeletal fluorosis, and other adverse health effects. According to the Bureau of Indian Standards (BIS IS 10500:2012), the acceptable limit for fluoride in drinking water is 1.0 mg/L, while concentrations exceeding 1.5 mg/L are considered potentially harmful to human health (5, 6). In many parts of Karnataka, elevated fluoride concentrations continue to contribute to endemic fluorosis, adversely affecting the health and quality of life of rural communities. Community-based studies from Mundargi Taluk have reported that individuals affected by skeletal fluorosis commonly experience joint pain, stiffness, gastrointestinal disturbances, and reduced work efficiency, with disease severity increasing with age (1).

In addition to chemical contamination, microbiological contamination of potable water remains a major public health concern, particularly in rural schools where inadequate sanitation and limited water treatment facilities increase the risk of waterborne diseases. Ensuring microbiologically safe drinking water is therefore essential for protecting children's health. Recent studies have emphasized the importance of regular monitoring of drinking water quality in schools and the implementation of effective water treatment strategies to minimize microbial contamination and improve water safety (3, 5, 7).

Government primary schools in rural areas represent important settings for safeguarding child health through the provision of safe drinking water. The coexistence of excessive fluoride levels and microbial contamination creates a dual burden of chemical and biological hazards for school children. Therefore, comprehensive assessment of both fluoride concentration and microbial quality is essential for identifying potential health risks and planning appropriate preventive measures. The implementation of decentralized water treatment systems and regular water quality surveillance has been shown to significantly improve drinking water safety in rural educational institutions (7).

Accordingly, the present study was undertaken to assess the microbial quality and fluoride content of potable water collected from Government Primary Schools in Doni and Kalkeri villages of Mundargi Taluk, Gadag District, Karnataka, India. The findings of this study are expected to provide baseline information on water quality and support the development of targeted interventions for preventing fluorosis and waterborne diseases among rural school children.

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

Safe potable water is fundamental to public health and is essential for the healthy growth and development of children. In rural areas of India, groundwater is the primary source of drinking water; however, it is often affected by both fluoride contamination and microbial pollution. Prolonged consumption of water containing fluoride concentrations above the permissible limit can result in dental and skeletal fluorosis, whereas microbiologically contaminated water increases the risk of waterborne diseases such as diarrhoea, typhoid, dysentery, and gastroenteritis.

Fluorosis is recognized as a major public health problem in more than 24 countries worldwide and is primarily caused by long-term consumption of fluoride-contaminated drinking water. According to the Bureau of Indian Standards (BIS), the acceptable limit of fluoride in drinking water is 1.0 mg/L, while concentrations exceeding 1.5 mg/L are considered potentially hazardous to human health. Although defluoridation techniques can reduce fluoride exposure and prevent further progression of fluorosis, they cannot reverse the irreversible damage caused during tooth enamel development. Therefore, early detection and regular monitoring of fluoride levels are essential for effective prevention and control.

In addition to chemical contamination, microbiological contamination remains a significant concern in rural drinking water supplies due to inadequate sanitation, poor maintenance of water sources, and insufficient water treatment facilities. Since school children are particularly vulnerable to the adverse effects of unsafe drinking water, routine assessment of both fluoride concentration and microbial quality is necessary to ensure safe potable water in educational institutions.

Considering the dependence of rural communities on groundwater and the limited information available on the combined assessment of fluoride and microbial contamination in Mundargi Taluk, the present study was undertaken to evaluate the microbial quality and fluoride content of potable water sources in Government Primary Schools of Doni and Kalkeri villages, Karnataka. The findings of this study will provide baseline information to support appropriate interventions for improving drinking water quality and reducing the burden of fluorosis and waterborne diseases in the study area.

The aim of the present study was to assess the microbial quality and fluoride concentration of potable water sources in Government Primary Schools located in Doni and Kalkeri villages, Mundargi Taluk, Karnataka, India. The study further aimed to evaluate the microbiological quality and fluoride levels of the available potable water sources and determine their suitability for human consumption in accordance with the permissible standards prescribed by the Bureau of Indian Standards (BIS). In addition, the study sought to generate baseline data that could support the development and implementation of appropriate preventive and mitigation measures for reducing the risks of fluorosis and waterborne diseases among the school population and the wider community in the study area.

Methodology

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.

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.

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.

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

Results and Discussion

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.

Assessment of fluoride content of water samples

Results were statistically analysed. The research results show that:

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.

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.

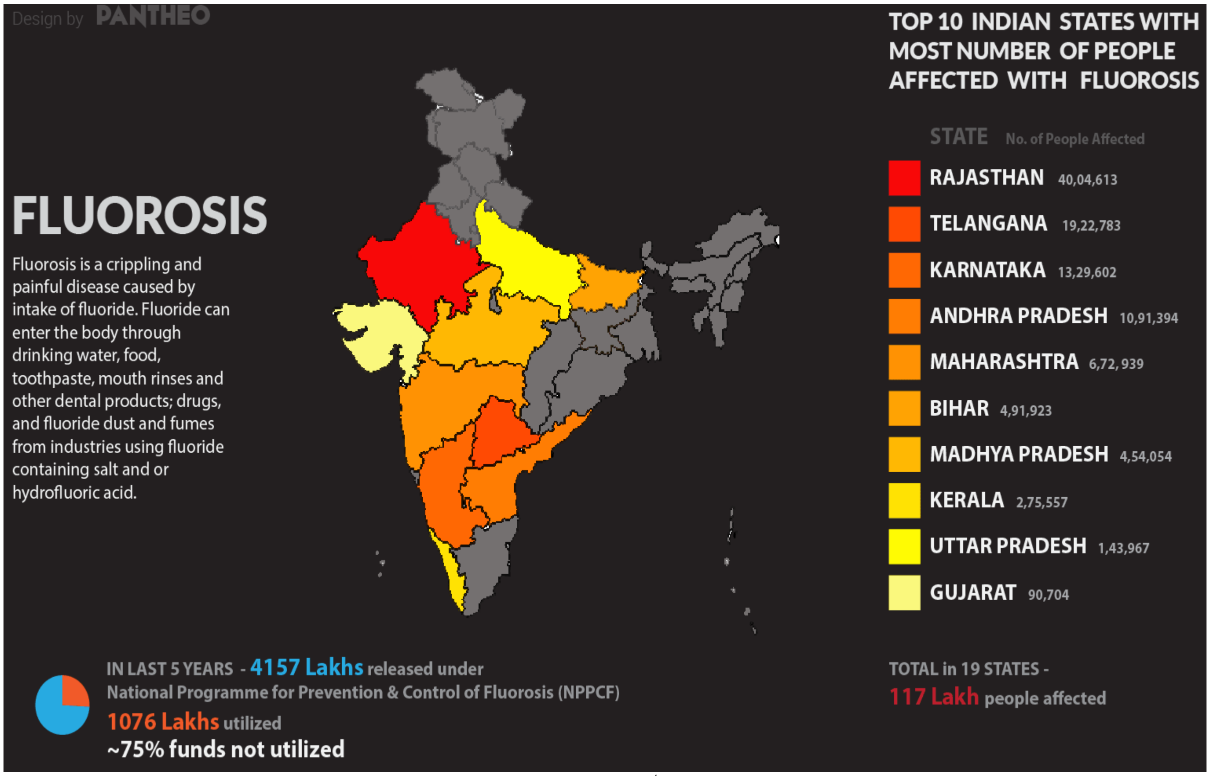
Implications

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.

Fig.1 Top 10 Indian states affected with Fluorosis.



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

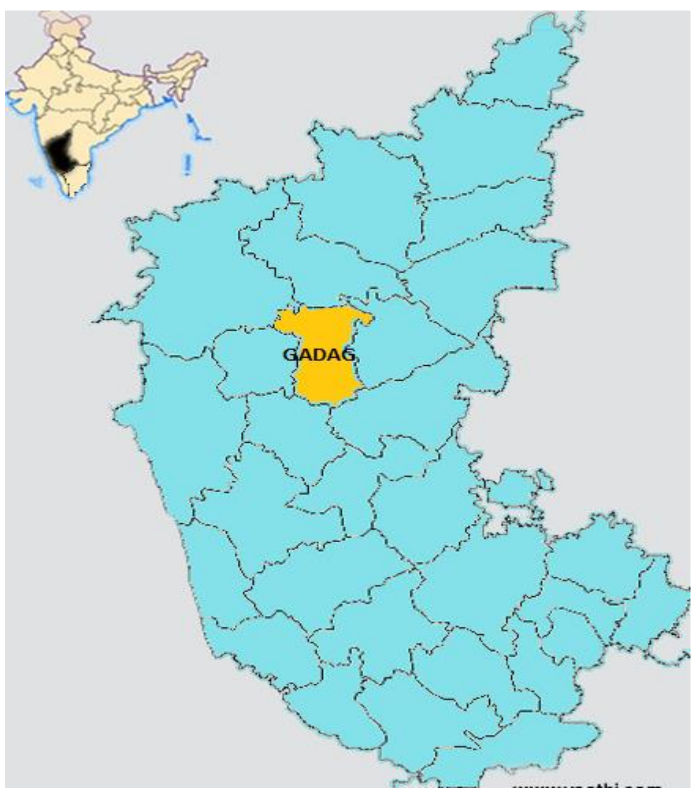


Fig.2 Water samples fluoride content of Kalkeri village.

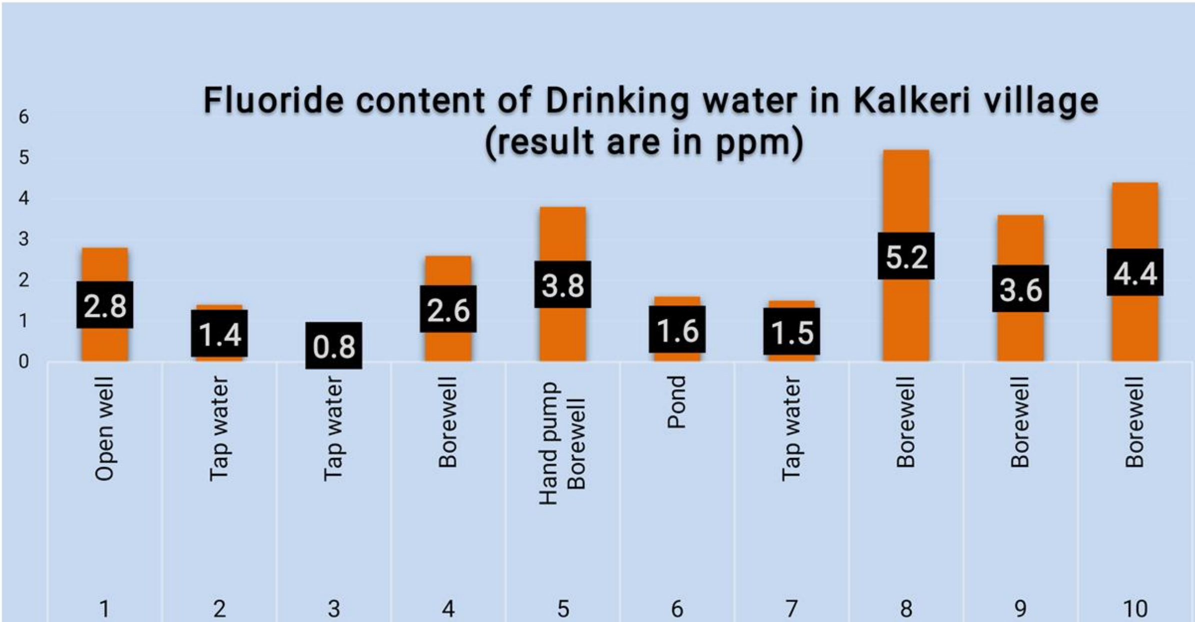
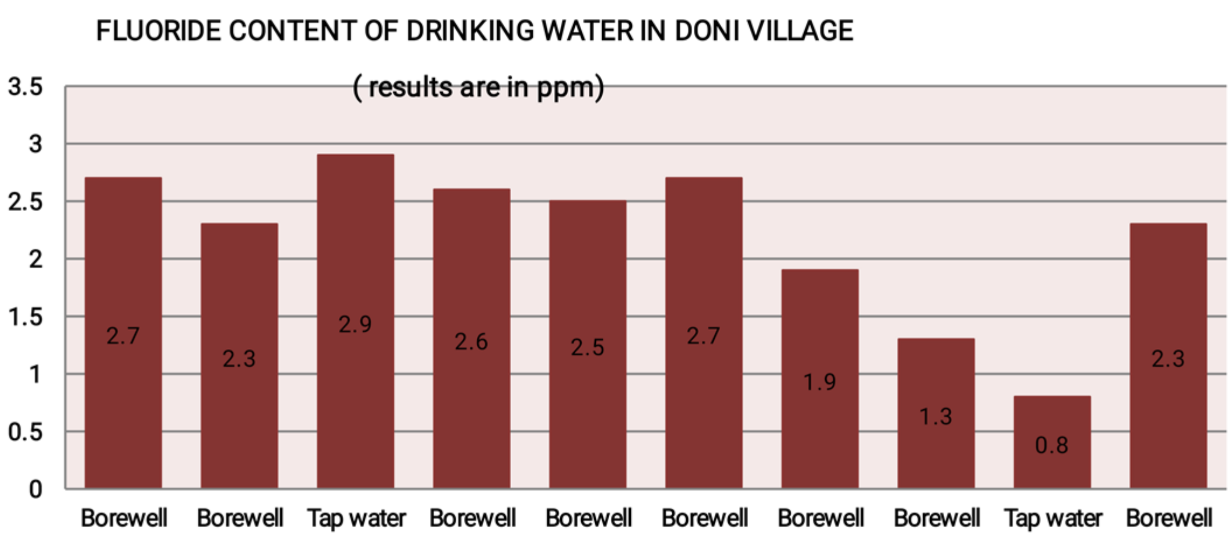


Fig.3 Water samples fluoride content of Doni village.



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.

The present study demonstrated that the majority of potable water sources in Government Primary Schools of Doni and Kalkeri villages, Mundargi Taluk, Karnataka, were unsuitable for human consumption due to the combined presence of excessive fluoride levels and microbial contamination. Of the 20 water samples analyzed, 18 exceeded the Bureau of Indian Standards (BIS) permissible limit for fluoride, while only two samples met the recommended standard. Similarly, microbiological analysis revealed that only two water sources were free from *Escherichia coli* contamination, whereas the remaining samples were microbiologically unsafe for drinking. These findings indicate a dual burden of chemical and biological contamination, posing a significant public health risk to school children and increasing their susceptibility to fluorosis and waterborne diseases.

The study highlights the urgent need for regular monitoring of potable water quality in rural schools, along with the implementation of appropriate water treatment measures such as defluoridation, filtration, chlorination, and periodic microbiological surveillance. Strengthening community awareness regarding safe drinking water practices and ensuring compliance with BIS drinking water standards are essential to safeguard children's health. The baseline data generated by this study can support local health authorities and policymakers in planning targeted interventions to improve rural drinking water quality and reduce the burden of fluorosis and waterborne illnesses in Mundargi Taluk and similar fluoride-endemic regions.

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