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ASSESSMENT OF FLUORIDE CONCENTRATION IN GROUNDWATER: A CASE STUDY OF JATUSANA BLOCK, REWARI DISTRICT, HARYANA

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Abstract

This study assesses fluoride contamination in groundwater across villages of Jatusana Block, Rewari District, Haryana. Groundwater samples from 55 villages were analyzed using the Ion-Selective Electrode (ISE) method to measure fluoride levels. Results indicated fluoride concentrations ranging from 0.1 mg/l to 1.2 mg/l. Most villages had fluoride levels within the World Health Organization's (WHO) safe drinking water limit (≤1.0 mg/l). However, villages like Khushpura, Sihas, Basota, and Jaruwas exhibited elevated fluoride concentrations (≥1.1 mg/l), posing risks of dental and skeletal fluorosis. Statistical analysis demonstrated that fluoride distribution varied significantly across the region, highlighting localized health risks. The median fluoride concentration was approximately 0.5 mg/l, with most samples falling between 0.4 mg/l and 0.7 mg/l. This variability emphasizes the need for targeted public health interventions, including fluoride removal techniques in areas of high fluoride and potential fluoride supplementation where levels are low (≤0.2 mg/l). Regular monitoring, community awareness programs, and improved water management policies are recommended to safeguard public health and ensure sustainable water quality across Jatusana Block.

1. Introduction

Groundwater is an essential resource, especially in rural areas where it serves as the primary source of drinking water and irrigation (Kumar & Kumar, 2021). In recent years, fluoride contamination of groundwater has emerged as a significant public health concern in various regions globally, including many parts of India (Rao et al., 2017). Fluoride is naturally present in groundwater due to geological processes, primarily the dissolution of fluoride-bearing minerals such as fluorite, apatite, and mica (Ayoob & Gupta, 2006). Although moderate fluoride intake (0.5–1.0 mg/l) is beneficial for dental health, prolonged exposure above permissible limits (>1.5 mg/l) can lead to serious health problems such as dental fluorosis, skeletal fluorosis, and various neurological disorders (WHO, 2017).

Jatusana Block, located in Rewari District of Haryana, India, predominantly depends on groundwater for drinking, domestic use, and irrigation. Recent assessments indicate varying fluoride concentrations across villages in this block, highlighting the necessity of comprehensive analysis and targeted interventions to mitigate potential health risks. Therefore, this study investigates groundwater fluoride contamination levels in the Jatusana Block, identifying high-risk areas, and recommending suitable public health actions.

2. Literature Review

Groundwater quality in India has attracted significant attention due to widespread issues of fluoride contamination. Several studies have reported fluoride concentrations exceeding the recommended safe limits of 1.0–1.5 mg/l by WHO in many regions, highlighting the widespread nature of the problem (Susheela, 1999; Brindha & Elango, 2011). High fluoride content in drinking water is recognized as the primary cause of fluorosis, characterized by dental mottling, weakening of bones, joint stiffness, and pain (WHO, 2017).

Studies conducted in various regions of India, including Rajasthan, Haryana, Punjab, and Uttar Pradesh, have highlighted the spatial variability and public health implications of fluoride contamination in groundwater (Yadav et al., 2019; Sharma & Singh, 2019). Specifically, Haryana faces significant challenges related to fluoride contamination due to its geological and climatic conditions. A study by Meenakshi and Maheshwari (2006) reported fluoride levels exceeding permissible limits in groundwater of various districts in Haryana, thereby necessitating regular monitoring and management interventions.

In Rewari District specifically, groundwater fluoride contamination has been documented in past studies, with many villages exhibiting elevated fluoride concentrations above permissible limits, particularly in rural areas reliant on groundwater sources (CGWB, 2015). Despite these findings, comprehensive studies specific to the Jatusana block are relatively limited, thereby creating a significant gap in understanding fluoride exposure risks for local populations.

Considering these factors, the present study aims to investigate groundwater fluoride concentrations systematically across multiple villages within the Jatusana block. The objectives are to assess the spatial distribution and health implications of fluoride concentrations, providing critical insights that could guide public health measures and groundwater management policies.

3. Analysis of fluoride in Water (Methodology)

Water samples from diverse drinking water sources (hand pumps, open wells, and tube wells) were obtained from villages/sites within the Rewari block of Rewari district to ascertain the fluoride concentration. The geographic coordinates of sampling sites were delineated using the Global Positioning System (GPS). Samples were collected in prewashed plastic containers and sent to the laboratory. The collected samples were stored in a dark location at room temperature in plastic containers until the fluoride analysis was conducted. The ion-selective electrode (ISE) method was employed to ascertain the fluoride concentration in drinking water. The electrode was calibrated via a series of known fluoride concentrations. Standards and samples were combined in a 1:1 ratio with a total ion strength adjustment buffer (TISAB) to mitigate the effects of fluctuating ionic strength and interference from other ions. TISAB was prepared using 4.00 g of CDTA (cyclohexanediamino-NNN1N1-tetraacetic acid), 57 g of NaCl, and 57 g of glacial acetic acid in 1 L, adjusted to pH 5.5 with 5 M NaOH. Following the addition of 25 ml of TISAB to 25 ml of a water sample, the

fluoride content was quantified using a fluoride ion-selective electrode in mg/l or ppm/l. Various quantities of NaF, ranging from 0.1 to 100 ppm, were utilised to produce the standard curve for fluoride. Appropriate statistical methods and graphical representations were employed for analysis. GIS tools are utilised to display fluoride concentration on a map.

4. Results

Ground water fluoride concentration (measured in milligrams per liter, mg/l) in various villages of Jatusana. It lists each village name along with its respective fluoride concentration level (Table 1). The fluoride levels listed range from as low as 0.1 mg/l to as high as 1.2 mg/l, indicating variation in groundwater quality across these villages. The safe limit recommended by the World Health Organization (WHO) for fluoride in drinking water is generally around 1.0 mg/l, with levels exceeding 1.5 mg/l considered potentially harmful. Thus, most of these villages are within safe limits, but villages like Khushpura, Sihas, Basota, and Jaruwas slightly exceed the typical recommended level of 1.0 mg/l, indicating potential risks for dental or skeletal fluorosis if consumed regularly.

Table 1 Fluoride concentrations (mg/l) in groundwater across various villages within Jatusana Block, Rewari District.

S.NO.	**Village Name**	**Fluoride** (mg/l)
1.	Baldhan Kalan	0.9
2.	Baldhan Khurd	0.6
3.	Chowki No.2	0.5
4.	Khushpura	1.2
5.	Babdoli	0.6
6.	Bohatwas Bhondu	0.8
7.	Gopalpur Gazi	0.4
8.	Murlipur	0.1
9.	Nangal Pathani	0.7
10.	Sihas	1.2
11.	Asiaki Gorawas	0.5
12.	Basota	1.1
13.	Berli Kalan	0.9
14.	Chandanwas	0.7
15.	Chang	0.6
16.	Chowki No.1	0.3
17.	Gadhla	0.8
18.	Gurawra	0.6
19.	Hansawas	0.9
20.	Jaruwas	1.2
21.	Jatusana	0.4
22.	Jeewra	0.5
23.	Kanhora	0.6
24.	Kanhori	0.8

25.	Karawra Manakpur	0.4
26.	Katopuri Bujurg	0.6
27.	Khera Alampur	0.7
28.	Lala	0.1
29.	Maliaki	0.3
30.	Mastapur	0.2
31.	Mohdinpur	0.4
32.	Mundawas	0.4
33.	Musepur	0.7
34.	Nain Sukhpura	0.9
35.	Nanglia Ranmokh	0.8
36.	Nurpur	0.3
37.	Pahrajwas	0.4
38.	Palhawas	0.3
39.	Parkhotampur	0.1
40.	Prithvipura	0.6
41.	Rasoolpur	0.7
42.	Rohrai	0.1
43.	Rojhuwas	0.4
44.	Saidpur	0.8
45.	Shadipur	0.5
46.	Suma Khera	0.3
47.	Tehana Depalpur	0.2
48.	Berli Khurd	0.1
49.	Biharipur	0.5
50.	Boria Kamalpur	0.4
51.	Dohkia	0.3
52.	Haluhera	0.5
53.	Mandhia Khurd	0.6
54.	Rajawas	0.8
55.	Rasuli	0.3

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4.1 Histogram of Fluoride Level:

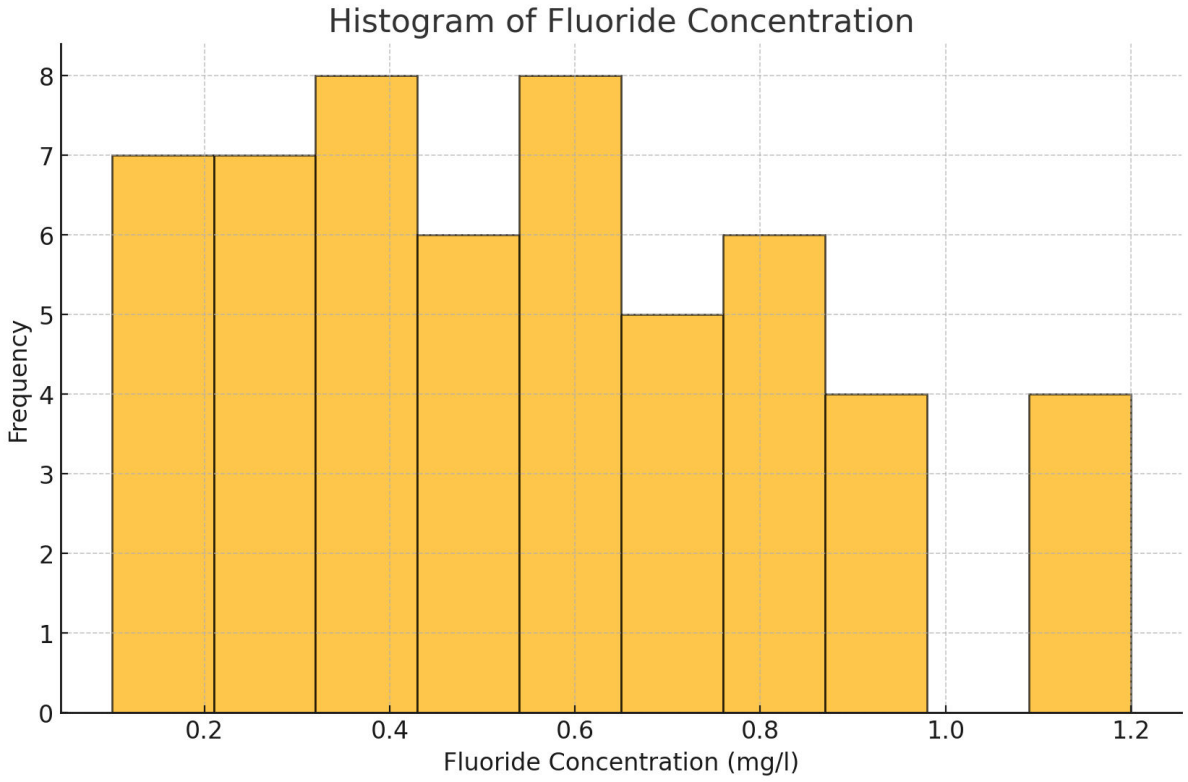

Figure 1 Histogram of Fluoride Concentration in Groundwater of Jatusana Block

This histogram represents the distribution of fluoride concentration levels (in mg/l) in groundwater across various villages within the Jatusana block. The x-axis indicates fluoride concentration values, while the y-axis shows the frequency (number of villages) within each concentration interval.

- Fluoride concentrations range between approximately **0.1 mg/l and 1.2 mg/l**.
- Most villages have fluoride concentrations within the safe range of 0.2 to 0.8 mg/l.
- A smaller number of villages exhibit elevated fluoride concentrations (up to 1.2 mg/l), suggesting potential public health concerns in those specific areas.

The distribution in figure 1 indicates that groundwater in most villages of Jatusana block is within safe consumption limits, though targeted actions may be required for villages on both extremes—low or slightly elevated fluoride levels.

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4.2 Scatter Plot of Fluoride Levels by Village:

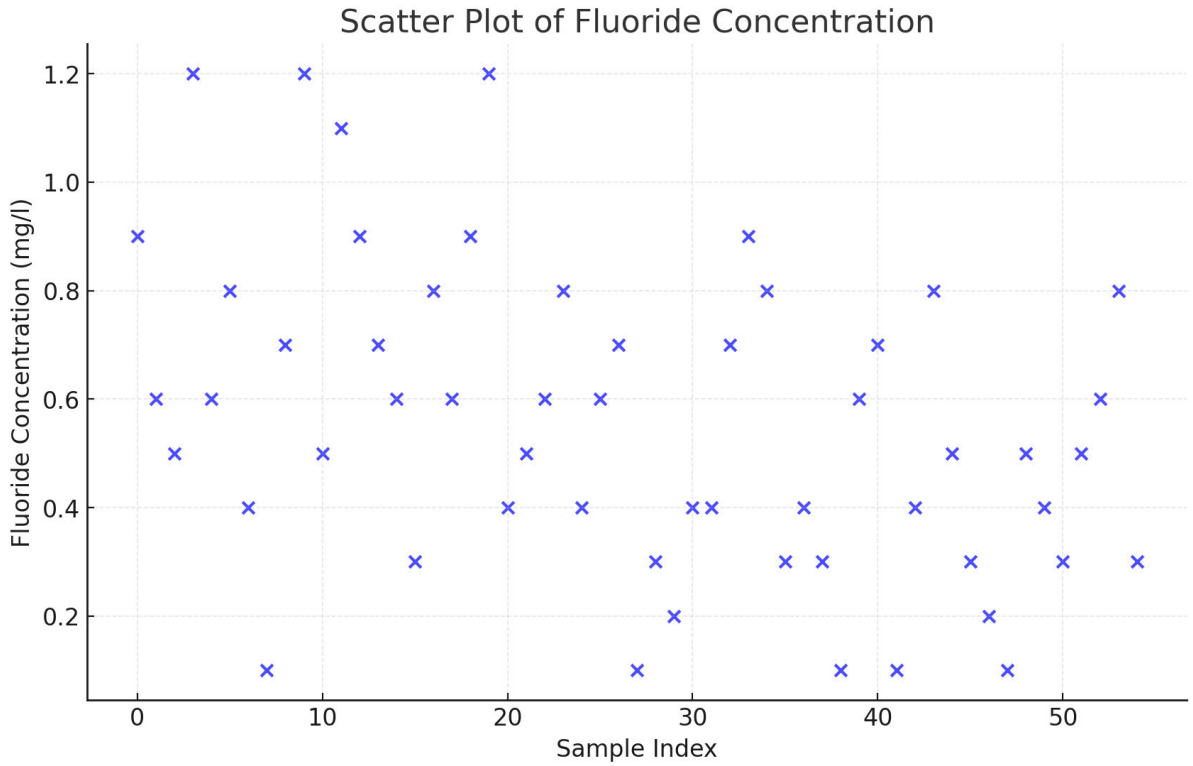

Figure 2: Scatter Plot of Fluoride Concentration in Groundwater Samples from Jatusana Block

This scatter plot illustrates the fluoride concentrations (in mg/l) measured in groundwater samples across various villages within the Jatusana block. The x-axis represents individual sample indices, corresponding to specific villages sampled, and the y-axis shows the fluoride concentration levels.

- Fluoride concentrations range from **0.1 mg/l to 1.2 mg/l**.
- The distribution of fluoride concentrations appears scattered, indicating variability without a clear trend across the samples.
- Several samples recorded fluoride concentrations around or above the recommended limit (**1.0 mg/l**), highlighting areas at potential risk for fluorosis.
- Most samples fall within the optimal fluoride range (0.5-1.0 mg/l), indicating generally acceptable groundwater quality for consumption.

This figure 2 emphasizes the diversity in groundwater fluoride content within the Jatusana region, supporting the necessity for localized water quality monitoring and tailored public health interventions.

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4.3 Bar Plot by Fluoride Level Categories:

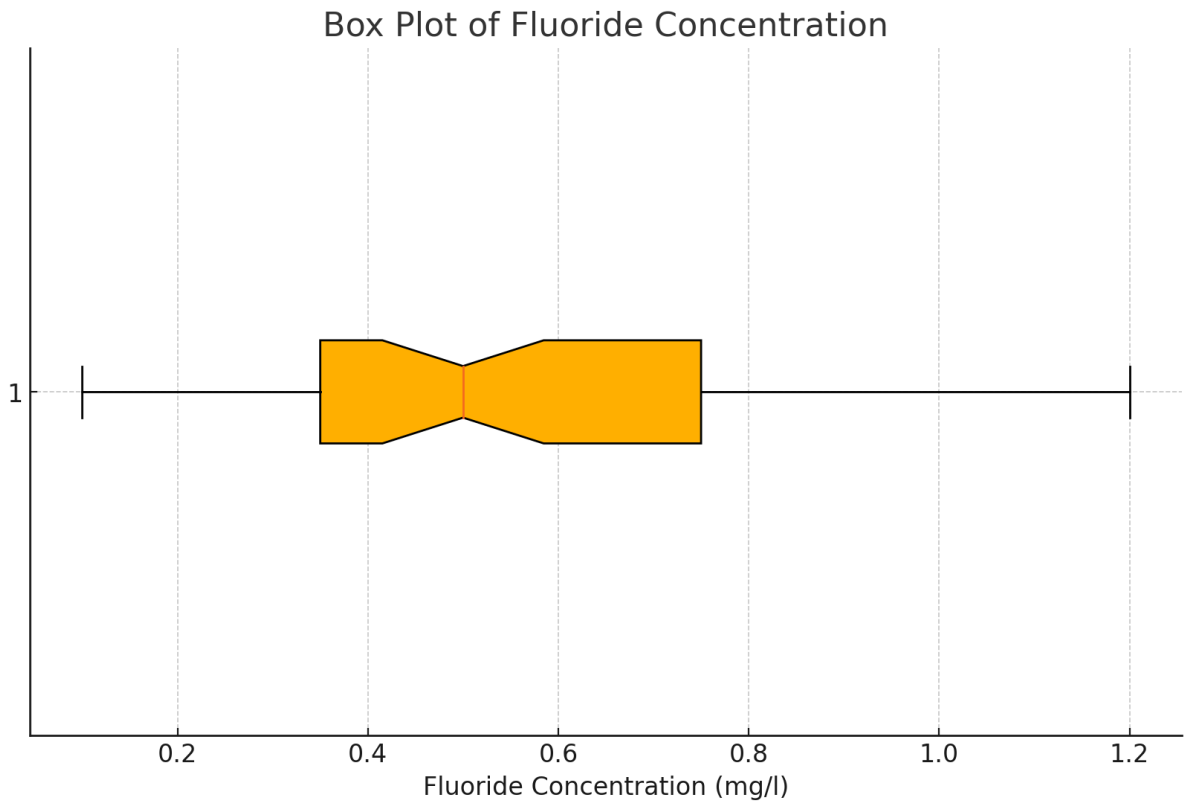

Figure 3 Box Plot of Fluoride Concentration in Groundwater of Jatusana Block

This box plot figure 3 provides a statistical summary of fluoride concentration levels (mg/l) measured in groundwater across Jatusana block villages. It visually represents the distribution, central tendency (median), variability (interquartile range), and presence of potential outliers in the data.

- **Median (central line in the box)** is approximately **0.5 mg/l**, suggesting that half of the groundwater samples have fluoride concentrations above this value, and half below.
- **Interquartile Range (IQR)**, represented by the box itself, shows most samples fall between approximately **0.4 mg/l to 0.7 mg/l**.
- **Whiskers** extend from around **0.1 mg/l (minimum)** to **1.2 mg/l (maximum)**, indicating the complete range of fluoride concentration.
- No points are marked separately outside the whiskers, suggesting the absence of statistically significant outliers.

The box plot suggests that groundwater fluoride concentration in Jatusana generally remains within safe limits, but the extremes highlight both potential deficiency and excess of fluoride, each requiring different public health approaches.

5. Conclusion

This study assessed the fluoride concentration in groundwater across various villages in Jatusana Block, Rewari District. The fluoride concentrations measured ranged from **0.1 mg/l to 1.2 mg/l**, indicating considerable spatial variability in groundwater quality. Most villages had fluoride levels within the safe limits recommended by the World Health Organization (WHO), which is generally around **1.0 mg/l**. However, villages such as **Khushpura, Sihas, Basota, and Jaruwas** recorded slightly elevated fluoride concentrations (**≥ 1.1 mg/l**), highlighting potential health risks like dental and skeletal fluorosis if consumed regularly over prolonged periods. Statistical analysis from histograms, scatter plots, and box plots supports the conclusion that groundwater fluoride levels predominantly fall within acceptable ranges (**0.4-0.7 mg/l median range**). Nevertheless, the existence of villages on both ends of the spectrum—extremely low fluoride concentrations (**≤0.2 mg/l**) and slightly elevated levels (**≥1.1 mg/l**)—requires targeted public health interventions. Specifically, fluoride-removal strategies, water treatment measures, or provision of alternate safe drinking sources might be essential for high-fluoride areas, while fluoride supplementation strategies could benefit low-fluoride areas. Regular groundwater monitoring and focused community awareness programs are recommended to manage fluoride exposure effectively, ensuring sustainable water quality and improved public health outcomes across the Jatusana Block.

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