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FLUORIDE CONCENTRATION IN GROUND WATER FROM BADHRA TEHSIL OF CHARKHI DADRI DISTRICT, HARYANA, INDIA

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Abstract

This study aimed to evaluate the fluoride concentration in groundwater sources of Badhra Tehsil, Charkhi Dadri District, utilizing the ion-selective electrode method, and to assess the potential health risks associated with varying fluoride levels. Water samples were collected across 21 villages in the Badhra Tehsil during May 2023. These samples underwent analysis to determine fluoride concentrations, employing an ion-selective electrode method. The samples were collected from hand-pumps, wells, and tubewells, and were tested in a laboratory within 6–12 hours of collection. The fluoride concentration in groundwater samples ranged from 0.01 to 8.20 mg/ltr. While most villages had fluoride levels within safe drinking limits, the villages of Dagroli, Kakroli Hukmi, and Nimarh exhibited fluoride concentrations of 5.80 mg/ltr, 4.40 mg/ltr, and 8.20 mg/ltr, respectively substantially surpassing the WHO recommended limits and indicating a potential public health concern. However, the significantly high levels of fluoride in specific villages raise concerns for public health, necessitating immediate remedial actions such as the provision of alternative water sources, public awareness campaigns, and the introduction of defluoridation measures.

Keywords: Groundwater, Fluoride Concentration, Health Risks, Ion-Selective Electrode Method, Public Health, Badhra Tehsil, Fluorosis.

INTRODUCTION

Now a days, the wellbeing of people is significantly influenced by the quality of the water. The definition of water quality involves description of chemical, physical, and biological properties of water. Water is involved in many biological processes, making it vital to life and to the healthy development of our bodies. In addition to meeting many other needs, water is utilised for drinking, irrigation, and sanitation. It has an impact on our way of life and financial stability. More than 75 percent of the surface of the world is covered by water, yet only 2.8% of that water is suitable for consumption of human; the remaining 97.2% is found in oceans. The water resources have been exposed and deteriorated as a result of the rapidly growing population, rising standards of living, and exponential rise of industrialisation and urbanisation. Domestic and industrial wastes that are dumped into natural water bodies are the main causes of water pollution [1-3]. Herbicides, pesticides, fertilisers, toxic polychlorinated biphenyls, and synthetic organic compounds can all enter the water supply as pollutants. A significant contributor to the pandemic and chronic diseases affecting people is contaminated ground water. Numerous studies have revealed a relationship between water composition and cardiovascular mortality [4, 5].

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Drinking water high in fluoride is the cause of the condition of the teeth and bones [6]. Both carbonate and bicarbonate may result from the microbial breakdown of organic materials. Alkalinity is a major issue for companies as well, as using alkaline water in boilers for the production of steam can result in scale buildup, sludge precipitation, and caustic embrittlement [7]. Due to the household garbage's disposal into ponds and pits, which causes the waste to migrate into the water table [8]. There is also a chance that some of the waste could dissolution of rocky materials in the area. Haryana residents are largely dependent on groundwater supplies because surface water. Groundwater serves as the only source of drinking water in many parts of the state. Fluorine is a naturally occurring element that is found in various places, such as rocks, minerals, water, and soil. Fluorine is the halogen with the highest electronegative property in the periodic table and is an essential component (number 13) in the Earth's crust with an average concentration of 625 mg kg^{-1}. The environment can be exposed to fluoride from geogenic and human-made sources [9].

Table 1.1: Concentration of F^- in different rocks [9].

Rocks	F^- range (ppm)	Average (ppm)
Basalt	20–1060	360
Gneisses and Granite	20–2700	870
Clay and Shale	10–7600	800
Limestones	0–1200	220
Sandstone	10–880	180
Phosphorite	24000–41500	31000
Coal (ash)	40–480	80

Table 1.2: Major geogenic sources of fluoride [9].

Mineral	Chemical formulae
Fluorspar/ fluorite,	CaF_2
Cryolite	Na_3AlF_6
Fluorapatite	$Ca_5(PO_4)_3F$
Villiaumite	NaF
Topaz	Al_2SiO_4 (F, OH_2)
Apatite	Ca_5(Cl, F, OH) $(PO_4)_3$
Mica	$(AB_{2-3}[X,Si]_4)_{10}(O,F,OH)_2$
Amphiboles	$A_{0-1}B_2C_5T_8O_{22}$(Cl, F, OH)
Sellaite	MgF_2

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Wells, tube-wells, and hand pumps are the primary sources of fresh water for drinking in rural areas. In contrast to rural areas, where the supply is constant after 4 to 5 days, municipal supply water is only available in metropolitan areas for brief periods of time. As a result, both in rural and urban regions, people are driven to use ground water for drinking and cooking. Additionally, groundwater is utilised for irrigation, and irrigation programmes are essential to the economy of any region, state, or nation [10].

MATERIAL AND METHODLDOGY

Site Specifications and Sampling

The study targeted the Badhra Tehsil within Charkhi Dadri District, located in the state of Haryana, India. Positioned 145 kilometers east of Delhi, 44 kilometers southwest of Bhiwani, and 37 kilometers west of the Charkhi Dadri district headquarters, Badhra's geographic coordinates are 28.5125° N latitude and 75.9450° E longitude. The region experiences a semi-arid climate, with temperature fluctuations between 2°C and 45°C, and receives an annual rainfall of approximately 483mm, primarily during July and August. The landscape is characterized by a flat and leveled plain, punctuated occasionally by sand dunes, isolated hillocks, and rocky ridges. For this study, all 21 villages of the Badhra Tehsil were included, focusing on groundwater as the primary source for agriculture and human consumption. Sampling occurred in May 2023.

Water Samples Collection

Water samples were collected from the 21 villages of Badhra Tehsil. The primary water sources were hand-pumps, wells, and tubewells, reflecting the local reliance on groundwater for both agricultural and domestic use. Before collection, these sources were operated for 4-6 minutes to stabilize the water's temperature, conductivity, and pH levels. Samples were then gathered in 200ml capacity plastic bottles, which had been pre-cleaned and sterilized. To prevent contamination, the bottles were immediately sealed with their caps. Following collection, the samples were transported to the laboratory at Baba Mastnath University, Rohtak, for analysis. To ensure accuracy, the ion-selective electrode method was employed within 6–12 hours post-collection.

Methodology for Fluoride Concentration Determination

The determination of fluoride concentration in the collected water samples was conducted using an electrochemical approach. A Cole-Parmer Fluoride Electrode, specifically designed to measure fluoride ions in aqueous solutions, was utilized for this purpose. This method is suitable for analyzing fluoride levels in drinking water, covering a broad concentration range from 0.1 to 1000 mg/l. The procedure commenced with the preparation of a stock solution of sodium fluoride at a concentration of 100 mg/l. From this stock, standard solutions ranging from 0.1 to 10 mg/l were prepared. To ensure accurate measurement, water samples were diluted with an equal volume of Total Ionic Strength Adjustment Buffer (TISAB) before the estimation of fluoride levels.

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This methodology section outlines the detailed procedures and techniques utilized in the study, adhering to scientific research standards and ensuring the reliability of the findings on fluoride concentrations in the groundwater of Badhra Tehsil.

RESULT AND DISCUSSION

The groundwater fluoride concentration study in the Badhra Tehsil of Charkhi Dadri District revealed a range of fluoride levels, with the majority of the villages showing fluoride concentrations within safe drinking water standards showed in table 1. Notably, the World Health Organization (WHO) suggests a fluoride concentration of less than 1.5 mg/l for preventing dental fluorosis, while also considering local climatic conditions which may necessitate lower levels in warmer climates where water consumption is higher.

The results from the tubewell samples across different villages varied, with the majority reporting fluoride concentrations well below the WHO threshold. This suggests that for most villages, groundwater is suitable for consumption without the risk of fluoride-related health issues. However, two villages, Dagroli and Kakroli Hukmi, exhibited alarmingly high fluoride levels of 5.80 mg/l and 4.40 mg/l, respectively, far exceeding the recommended limits. Nimarh stood out with the highest fluoride concentration at 8.20 mg/l, indicating a severe public health concern.

The high fluoride levels in these particular villages could be a result of geological factors, such as the presence of fluoride-bearing minerals in the aquifer materials. Human activities, such as agriculture and the use of fluoride-containing pesticides and fertilizers, could also contribute to the increased fluoride content in groundwater.

The depth of the groundwater sources did not show a consistent correlation with fluoride levels, as the affected villages had similar depths to those with safe concentrations. This points towards localized factors influencing the fluoride levels rather than a regional trend across different groundwater depths.

Table 1: Fluoride Conc. in Groundwater Samples in Badhra Tehsil

Fluoride Conc. in Groundwater Samples in Badhra Tehsil					
Sr. No.	**Block**	**Name of Village**	**Source of Water**	**Reading (mg/ltr.)**	**GW Depth**
1	Badhra	Arya Nagar	Tubewell	0.09	220-250
2	Badhra	Badhra	Tubewell	0.06	225-250
3	Badhra	Badrai	Tubewell	0.02	300-350
4	Badhra	Berla	Tubewell	0.11	220-250
5	Badhra	Bhandwa	Tubewell	0.06	220-250
6	Badhra	Bhariwas	Tubewell	0.07	220-250
7	Badhra	Bhopali	Tubewell	0.06	220-250
8	Badhra	Bilawal	Tubewell	0.06	220-250
9	Badhra	Bindraban	Tubewell	0.08	220-250
10	Badhra	Chandwas	Tubewell	0.08	220-250
11	Badhra	Dagroli	Tubewell	5.8	220-250
12	Badhra	Dalawas	Tubewell	0.04	220-250
13	Badhra	Dandma	Tubewell	0.1	220-250
14	Badhra	Dhanasari	Tubewell	0.05	250

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15	Badhra	Dwarka	Tubewell	0.06	250
16	Badhra	Gopalwas	Tubewell	0.08	250-300
17	Badhra	Gopi	Tubewell	0.09	250
18	Badhra	Govindpura	Tubewell	0.08	250
19	Badhra	Gudana	Tubewell	0.09	250
20	Badhra	Hansawas Kalan	Tubewell	0.07	250
21	Badhra	Hansawas Khurd	Tubewell	0.07	250
22	Badhra	Haroda Kalan	Tubewell	0.08	250
23	Badhra	Harodi	Tubewell	0.07	250
24	Badhra	Hui	Tubewell	0.06	250
25	Badhra	Jagrambass	Tubewell	0.01	250
26	Badhra	Jeetpura	Tubewell	0.05	250
27	Badhra	Jewali	Tubewell	0.05	250
28	Badhra	Kadma	Tubewell	0.06	280-350
29	Badhra	Kakroli Hatti	Tubewell	0.06	250
30	Badhra	Kakroli Hukmi	Tubewell	4.4	250
31	Badhra	Kakroli Sardana	Tubewell	0.09	250
32	Badhra	Kanhra	Tubewell	0.09	250
33	Badhra	Kari Adu	Tubewell	0.1	250
34	Badhra	Kari Dass	Tubewell	0.08	250
35	Badhra	Kari Dharni	Tubewell	0.06	250
36	Badhra	Kari Mod	Tubewell	0.05	250
37	Badhra	Kari Rupa	Tubewell	0.06	250
38	Badhra	Kari Tokha	Tubewell	0.05	250
39	Badhra	Khorda	Tubewell	0.07	250
40	Badhra	Kishkandha	Tubewell	0.03	250
41	Badhra	Kubja Nagar	Tubewell	0.07	240
42	Badhra	Lad	Tubewell	0.05	240
43	Badhra	Ladawas	Tubewell	0.05	240
44	Badhra	Mandi Harya	Tubewell	0.07	240
45	Badhra	Mandi Kehar	Tubewell	0.08	240
46	Badhra	Mandi Piranu	Tubewell	0.04	240
47	Badhra	Nandha	Tubewell	0.08	240
48	Badhra	Nihalgarh	Tubewell	0.09	240
49	Badhra	Nimarh	Tubewell	8.2	240
50	Badhra	Panchgaon	Tubewell	0.09	240
51	Badhra	Pichopa Kalan	Tubewell	0.06	240
52	Badhra	Pichopa Khurd	Tubewell	0.04	250
53	Badhra	Shyam Kalan	Tubewell	0.06	240
54	Badhra	Sirsali	Tubewell	0.5	240
55	Badhra	Surajgarh	Tubewell	0.08	240
56	Badhra	Todi	Tubewell	0.07	240
57	Badhra	Umarwas	Tubewell	0.04	240

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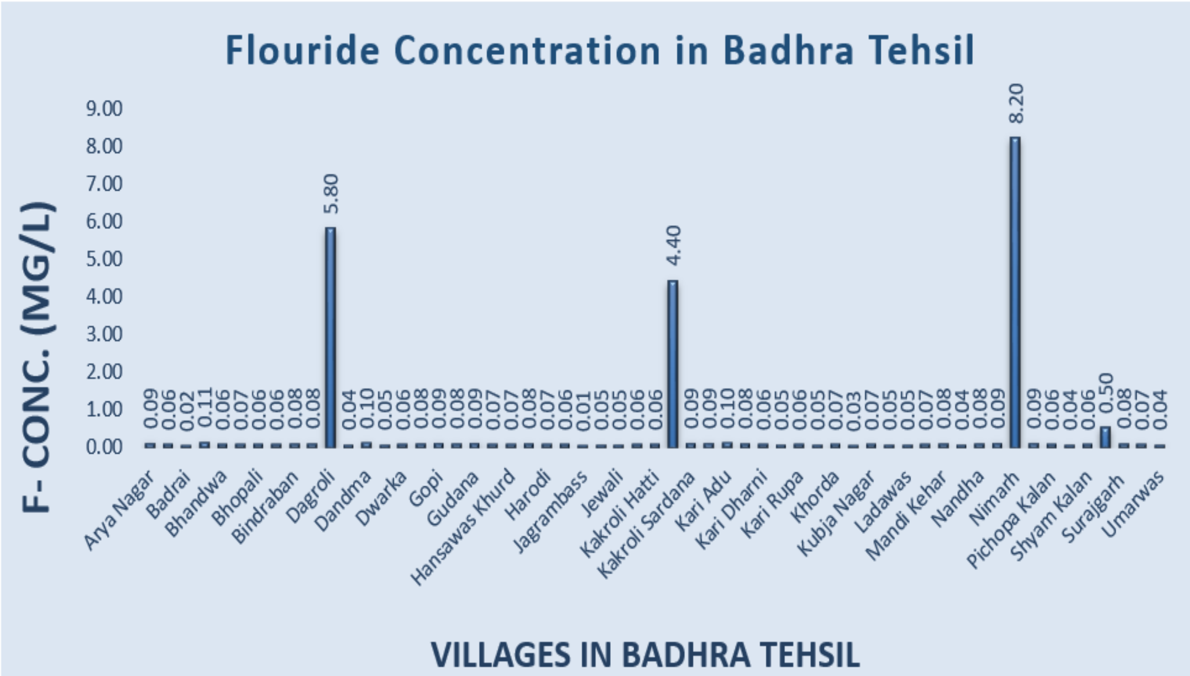

Figure 1: Flouride Concentration in Badhra Tehsil

The table 2 provided outlines the various effects of fluoride concentrations on human health and the environment, offering a clear guideline for understanding the potential impacts of the fluoride levels detected in the groundwater of Badhra Tehsil. At a concentration of 1 mg/ltr in water, fluoride is beneficial for reducing dental caries. However, as the concentration increases to 2 mg/ltr, it can cause dental fluorosis, indicated by mottled enamel.

Further exposure to higher concentrations, such as 8 mg/ltr in water, is associated with a 10% increase in the risk of osteoporosis. More severe health impacts are observed at even higher concentrations; for instance, levels exceeding 20-80 mg/day can result in crippling skeletal fluorosis, a debilitating condition affecting bones and joints.

The study's findings that the majority of water samples fell below these harmful thresholds are reassuring. Nonetheless, several villages reported fluoride concentrations that exceed safe limits, particularly Dagroli, Kakroli Hukmi, and Nimarh, with levels that could lead to serious health effects if not addressed. With Dagroli showing fluoride levels at 5.80 mg/ltr, Kakroli Hukmi at 4.40 mg/ltr, and Nimarh at 8.20 mg/ltr, residents are at risk of skeletal fluorosis and other related health issues.

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Table 2: F- Concentration and it's harmful Effects

F- Concentration and it's harmful Effects			
Sr. No.	**F- Conc.**	**Medium**	**Effects**
1	1 mg/ltr.	Water	Dental Caries Reduction
2	2mg/ltr.	Water	Mottled Enamel
3	0.002 mg/ltr.	Air	Injury to Vegetation
4	50 mg/ltr.	Food / Water	Change in Throid Harmone
5	> 20-80 mg/day	Human Body	Crippling Skeltal Fluorosis
6	8 mg/ltr.	Water	10% Osteoporosis
7	> 125 mg/ltr.	Human Body	Effect on Kidneys
8	100 mg/ltr.	Food / Water	Retardation in growth
9	3.1 to 6 mg/ltr.	Water	Osteoporosis
10	2.5-5.0 g	Human Body	Death

Given these findings, it's imperative to initiate public health measures, such as providing access to clean water with safe fluoride levels, to mitigate the health risks associated with high fluoride exposure. Additionally, ongoing monitoring and remediation efforts should be established to ensure the fluoride levels in groundwater do not reach the dangerous concentrations associated with chronic fluoride toxicity and its grave effects, such as osteoporosis and potential kidney damage.

These findings warrant immediate attention to the villages with high fluoride levels. Long-term exposure to high fluoride concentrations can lead to dental and skeletal fluorosis, which are major health issues. As a preventive measure, the residents of Dagroli, Kakroli Hukmi, and Nimarh should be advised to seek alternative water sources for drinking and cooking. Additionally, public health interventions, such as the installation of community water purification systems that can remove excess fluoride, would be beneficial.

Further studies should also be conducted to understand the source of the high fluoride concentrations. Geological surveys can help determine the presence of fluoride-rich minerals in the groundwater aquifers, and agricultural assessments may reveal the use of fluoride-containing compounds. Such comprehensive studies would aid in developing targeted strategies to mitigate the high fluoride levels in the affected areas of Badhra Tehsil.

CONCLUSION

The comprehensive study of fluoride concentration in the groundwater of Badhra Tehsil in Charkhi Dadri District, Haryana, India, has presented a multifaceted view of fluoride's prevalence and its potential impacts on public health. The ion-selective electrode method, utilized to analyze samples from 21 villages, highlighted that while most of the groundwater sources have fluoride concentrations within the safe limits prescribed by the World Health Organization, certain villages such as Dagroli, Kakroli Hukmi, and Nimarh have alarmingly high levels that could lead to adverse health effects, including skeletal fluorosis and osteoporosis.

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This variance in fluoride concentration is indicative of localized geological factors, anthropogenic activities, or a combination of both. These findings call for urgent intervention in affected areas, including alternative water sourcing, health education, and the implementation of defluoridation techniques. In light of the recognized benefits of fluoride at low concentrations, such as the reduction of dental caries, the study also underscores the delicate balance required in managing fluoride levels in drinking water. It calls for continued monitoring to safeguard against the harmful effects of excess fluoride while ensuring its dental health benefits are retained, maintaining the health and wellbeing of the Badhra Tehsil population. The results of this study not only contribute to the existing body of knowledge on groundwater quality but also serve as a critical tool for policymakers and health officials in prioritizing areas for resource allocation and preventive health measures.

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