Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 43 Issue: 08-2024
DOI: 10.5281/zenodo.13354442

ANALYZING FLUORIDE CONTAMINATION IN GROUNDWATER: CASE STUDIES OF REWARI BLOCK OF REWARI DISTRICT, HARYANA

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Abstract

This study investigates the fluoride concentration in drinking water across 84 villages in the Rewari Block of Rewari District, Haryana, India, a region with significant agricultural activity and semi-arid climate. Fluoride, a persistent pollutant, is naturally present in the Earth's crust and can accumulate in groundwater, particularly in regions with fluoride-bearing minerals. The study utilized the ion-selective electrode (ISE) method to measure fluoride levels in groundwater samples, finding concentrations ranging from 0.3 to 1.3 mg/L, which is within the permissible limit set by the World Health Organization (WHO). However, 21 villages reported levels exceeding the recommended 1.0 mg/L limit. The higher fluoride concentrations in some areas are attributed to geological factors, such as the presence of fluoride-rich rocks, deeper water tables, and specific climatic conditions. These findings highlight the need for targeted interventions by government and non-governmental organizations (NGOs) to mitigate the health risks associated with fluoride contamination in drinking water, particularly in rural and semi-arid regions dependent on groundwater sources.

Keywords: Fluoride Contamination, Groundwater, Ion-Selective Electrode, Fluorosis, Public Health.

INTRODUCTION

Globally, poor drinking water quality is responsible for approximately 80% of human diseases (WHO, 1984). Over 200 million people around the world rely on fluoride-contaminated water for drinking (Ayoob & Gupta, 2006). Fluoride is a persistent pollutant, highly phototoxic, and it accumulates in plants, soil, and water, ranging from low to high concentrations (Fornasiero, 2001). It is the 13th most abundant element in the earth's lithosphere (Gikunju et al., 1992). Naturally, fluoride levels in the atmosphere are around 0.5 mg/m³, but human activities can increase this concentration. In seawater, fluoride levels are approximately 1.3 mg/L, while in soil, they range from 20 to 500 mg/kg (Edmunds & Smedley, 2005). Fluorine is present in trace amounts in all types of foodstuffs (Kundu et al., 2001). It is an essential trace element that helps prevent dental caries, contributes to the formation of dental enamel, and aids in bone development (Park, 2011; McDonagh et al., 2000; Bouletreau et al., 2006; Messaitfa, 2008). While fluoride can come from various sources, the primary source is the ingestion of drinking water (Kumari & Rao, 1993).

Drinking water is the primary route through which fluoride enters the food chain. In small amounts, fluoride has beneficial effects on human health. However, if ingested in quantities above the permissible limit of 1.5 mg/L (WHO, 2002, 2011), it can cause dental and skeletal fluorosis (Sushila et al., 1993). Fluoride contamination in drinking water originates from both natural and human activities. Natural sources include marine

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aerosols, volcanic eruptions, and certain geothermal activities involving mineral-bearing rocks. In addition to these, anthropogenic sources such as industrial aerosols, phosphate fertilizer plants, sewage sludge, and pesticides significantly increase fluoride levels in soil and water (EPA, 1997; Fuge & Andrews, 1988; Cronin et al., 2000; Feng et al., 2003; Bonvicini et al., 2006; Walna et al., 2007). Other factors that influence fluoride levels in groundwater include temperature, pH of water and soil, soil's sorption capacity (Cronin et al., 2000), depth of wells, and the climatic conditions of a region (Handa, 1975).

The Earth's crust contains approximately 85 million tonnes of fluoride deposits, with 12 billion tonnes located in India alone (Teotia and Teotia, 1994). Regions with high fluoride concentrations include the East African Rift system (stretching from Jordan in northern Africa to Kenya and Tanzania in East Africa), large areas of the Middle East (Iraq, Iran, and Syria), the Indian subcontinent (Sri Lanka, Pakistan, India), Argentina, northern China, and the western USA. A survey conducted by Dissanayake (1991) in Sri Lanka revealed fluoride levels exceeding 4 mg/L. Another survey by Alabdulaaly et al. (2013) in 13 regions of Saudi Arabia analyzed 1060 water samples, reporting a maximum fluoride concentration of 5.40 mg/L in the Quassim province. The Geological Survey of India (GSI) has designated several areas as Red Alert zones for high fluoride levels: Nalgonda district in Andhra Pradesh; Gurgaon, Hisar, Fatehabad, Mahendergarh, and Rewari districts in Haryana; Fazilka and Jalalabad in the border district of Ferozpur in Punjab; Dindigul district in Tamil Nadu; Sindh district in Madhya Pradesh; Beed district in Maharashtra; and parts of Unnao, Rae Bareilly, and Sonbhadra in Uttar Pradesh. Studies on groundwater fluoride levels in India have shown high concentrations in various parts of the country (Gupta et al., 1993; Handa, 1975; Indu et al., 2007; Reddy et al., 2010).

In India, fluoride contamination ranges from 1.0 to 48.0 mg/L (Sushila, 2001). A survey conducted in Vellore District, Tamil Nadu, South India, found that fluoride concentrations in groundwater varied from 0.02 to 3.0 mg/L (Kumar et al., 2014). Dahariya et al. (2015) collected 48 groundwater samples from tubewells in Donagarh city, Chhattisgarh, India, during the pre-monsoon (May) and post-monsoon (January) periods of 2014. The fluoride concentrations ranged from 2.1 to 10.3 mg/L in the pre-monsoon and from 2.7 to 12.7 mg/L in the post-monsoon. In Alleppey, Kerala, Dhanya and Shaji (2017) observed fluoride levels ranging from 0.68 to 2.88 mg/L. In the current study, the fluoride concentration was examined in eight blocks of Rewari district in Haryana, India, using the ion-selective electrode method.

Study area

Rewari District, located in the southern region of Haryana, India, has historical importance and is seeing tremendous economic development. Situated at a latitude of around 28.19°N and a longitude of 76.62°E, it has boundaries with Gurgaon, Jhajjar, Mahendragarh, and the state of Rajasthan. The district encompasses a combination of flatlands and gently rolling landscapes, which are affected by the presence of the Aravalli hills. Rewari has a semi-arid climate with scorching summers, cold winters, and a monsoon season. The average annual rainfall of Rewari is between 500 and 600 mm. The Rewari Block is strategically situated and serves as the administrative center. It is

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characterized by a predominantly level landscape and is the most developed district, with Rewari city serving as the primary hub for commercial and service activities.

Analysis of fluoride in water

Water samples from various drinking water sources (hand pumps, open wells and tube wells) were collected from villages/sites of rewari block of Rewari district to determine the level of fluoride. Geographic locations of sampling sites were mapped by using Global Positioning System (GPS). Samples were collected in prewashed plastic bottles and carried to the laboratory. The collected samples were kept in dark place at room temperature in plastic containers until the fluoride analysis was done. Ion-selective electrode (ISE) method was used to determine the fluoride content in drinking water. Electrode was calibrated using a series of known concentrations of fluoride. Standards and samples were mixed with 1:1 with a total ion strength adjustment buffer (TISAB) to minimize the effects of varying ionic strength and interference from other ions. TISAB was made by using 4.00 g CDTA (cyclohexanedi-amino-NNN1N1 tetra acetic Acid) + 57 g NaCL and 57 g glacial acidic acid in 1 L of and 5.5 with 5 M NaOH. After adding 25 ml TISAB to 25 ml of a water sample, fluoride concentration was measured with fluoride ion-selective electrode in mg/l or ppm/l. The different concentrations of NaF ranging from 0.1 to 100 ppm were used for preparation of standard curve of fluoride. Suitable statistical techniques and graphical representations were used for analysis. GIS tools are used to show the fluoride concentration on map.

RESULTS

Ground water fluoride concentration at different sampling sites varied in different villages of Rewari block district Rewari. Fluoride level in water samples of 84 villages of Rewari block was examined and found that fluoride concentration ranged from 0.3 to 1.3 mg/l (Table 1). The study reveals that fluoride concentration in villages of Rewari block was found within upper prescribed limit of WHO.

Table 1: Showing the average fluoride concentration in villages of block Satnali district Mahendergarh

Village Name	Fluoride (mg/l)	Village Name	Fluoride (mg/l)
Kanhawas (189)	0.3	Bharawas (145)	1.1
Molawas (183)	0.5	Bhiwari (150)	1.2
Akbarpur (146)	0.4	Bhudpur (116)	0.9
Dana Alampur (140)	0.3	Bhurthal Jat (216)	0.6
Nangli Godha (141)	0.6	Bhurthal Thetar (215)	0.5
Thothwal (139)	0.5	Bikaner (221)	1.2
Chillar (259)	1.0	Bithwana (149)	0.4
Jaitpur Shekhpur (260)	0.4	Budana (202)	0.6
Aasaka (144)	0.6	Budani (208)	0.7
Ashapur (114)	0.8	Chandawas (117)	0.9
Balawas Ahir (128)	0.3	Chandpur (124)	1.3
Balawas Jamapur (109)	0.9	Chhuriawas (157)	1.1

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Village Name	Fluoride (mg/l)	Village Name	Fluoride (mg/l)
Bamber (182)	1.1	Chitarpur (207)	0.4
Bariawas (170)	0.4	Dabri (210)	0.9
Bhagwanpur (121)	0.9	Daliaki (133)	0.9
Devlawas (154)	0.4	Kaunsiwas (175)	1.3
Dhaliawas (173)	0.5	Khalilpuri (179)	0.9
Dhamlaka (155)	1.3	Kharagwas (127)	0.8
Dohki (120)	0.7	Kharkhari Bhiwa (142)	0.7
Fatehpuri Pipa(181)	1.1	Kharsanki (147)	1.2
Fideri (204)	0.5	Kishangarh (110)	0.8
Gajjiwas (153)	0.5	Ladhuwas Ahir (129)	1.3
Gangaycha Ahir (222)	1.1	Lakhnor (115)	1.2
Gangaycha Jat (223)	0.9	Lisana (220)	0.5
Gangli (135)	1.1	Majra Gurdas (176)	1.3
Ghurkawas (217)	0.8	Majra Sheoraj (180)	1.2
Gindo Khar (113)	0.7	Mandhia Kalan (178)	0.9
Gokalgarh (119)	0.4	Meerpur (274)	0.8
Gokalpur (211)	0.6	Mundhalia (218)	0.6
Hansaka (203)	0.9	Muradpuri (184)	0.3
Husainpur (134)	1.1	Narianpur (138)	0.4
Jadra (87)	0.9	Nayagaon (219)	0.8
Jaitrawas (143)	1.1	Pachlai (276)	0.7
Janti (212)	0.6	Padhiawas (172)	0.7
Jant Sairwas (213)	1.3	Pokharpur (206)	1.1
Jatuwas (148)	1.3	Qtabpur Jagir (205)	0.8
Kakoria (214)	1.2	Rajpura Khalsa (111)	0.4
Kalaka (177)	0.9	Ramgarh (209)	0.5
Kaluwas (118)	0.8	Rampura (132) (ct)	0.5
Kamalpur (152)	0.2	Saharanwas (130)	0.4
Kan Majra (126)	0.4	Shahbajpur Khalsa (171)	0.6
Karnawas (151)	0.3	Shekhpur Shikarpur (224)	0.4

DISCUSSION

Based on fluoride distribution, villages in the Rewari block of Rewari district were categorized following the pattern of a previous study (Yadav et al., 2009). Among the 84 villages in the Rewari Block, 21 reported fluoride levels exceeding the permissible limit set by the WHO and the Bureau of Indian Standards (1.0 mg/L). Various studies worldwide have documented high fluoride concentrations in groundwater. Boyle and Chagnon (1995) found fluoride levels up to 28 mg/L in shallow wells in the Gaspe Peninsula of Quebec, Canada. Gopalakrishnan et al. (2012) surveyed the Manur block of Tirunelveli district, Tamil Nadu, South India, identifying Alavanthankulam and Pappankulam as high fluoride endemic areas with levels of 3.6 and 2.00 mg/L, respectively. Behera et al. (2014) surveyed Purulia district, West Bengal, India, collecting

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84 water samples in January 2013 and reporting fluoride concentrations ranging from 0.126 to 8.16 ppm, with 23 samples exceeding the permissible limit.

In Haryana, several studies have analyzed groundwater fluoride concentrations. Meenakshi et al. (2004) reported fluoride levels in Jind district ranging from 0.3 to 6.9 mg/L. Bishnoi and Arora (2007) found that out of 63 water samples from ten villages in Rohtak district, 30 samples (about 50%) exceeded the permissible limit, with fluoride levels ranging from 0.034 to 2.09 mg/L. Manjeet et al. (2014) surveyed various villages in Gurgaon district, analyzing 97 water samples and finding fluoride levels between 0.02 and 6.4 mg/L. Kumar et al. (2017) studied the relationship between water, urine, and serum fluoride in Jhajjar district, reporting average fluoride levels of 2.17 mg/L in Jhajjar city and 2.81 and 2.22 mg/L in the villages of Dadanpur and Dariyapur, respectively.

Kumar and Sharma (2017) conducted a survey in Hisar city to analyze groundwater quality and found that fluoride concentrations ranged from 0.5 to 2.98 mg/L. Fluoride levels above 1.5 mg/L in drinking water can lead to various diseases, primarily dental and skeletal fluorosis. Mahendergarh district has a rural background, is an industrial-free zone, and has no industrial inputs. The main occupation of the residents is agriculture, so industrial aerosols are not responsible for the higher fluoride concentration. The geology of the area and the use of fertilizers in agriculture are possible contributors to the fluoride levels in groundwater. Geologically, the rocks in this area belong to the Delhi supergroup and are divided into two groups. The Purana rocks of the Upper Precambrian age belong to the Ajabgarh series of the Delhi system. The rocks of the Huranian period belong to the Archaean Dharwar system and consist of biotite, slates, phyllites, quartzite, limestone, gneiss, and sandstones. Fluorine is found in primary minerals, especially biotites and amphiboles. Upon weathering, fluorine leaches out from these minerals and becomes a major source of fluoride in groundwater.

Other reasons for higher fluoride concentrations in some villages may include a deeper water table and specific climatic conditions. Deeper groundwater in boreholes tends to contain higher fluoride levels than shallow groundwater boreholes. Climatic conditions also play a role in variations in fluoride concentration (Handa, 1975). Mahendergarh district lies in an arid climatic zone where groundwater infiltration and flow rates are slow. These conditions allow for extended interaction between water and rocks, resulting in higher fluoride levels in groundwater.

CONCLUSION

Rewari district is one of the district of Haryana known for high fluoride level where majority of resident's use underground water for drinking purpose. Fluoride level was measured in underground drinking water from84 villages in the present study.. The main economy of the people depends on agriculture. It lies in semiarid zone, and water table is very low. Higher fluoride range in ground water is due to the presence of fluoride bearing mineral rocks. The present study will be helpful to mitigate the problem of high fluoride level through implementation of program by government and NGO to achieve the goal of health for all.

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