Impact of Fluoride Contamination on Foodstuffs and Groundwater in Sanganer, Jaipur

*Dr. Surendra Singh Chauhan

Abstract

Fluorosis remains a significant public health challenge in the Sanganer block of Jaipur, Rajasthan. Research transitioned from examining drinking water alone to evaluating the "soil-plant-human" pathway. This paper analyzes fluoride (F-) concentrations in groundwater and various food crops (cereals, pulses, and vegetables) milks in Sanganer. Findings indicate that groundwater fluoride levels frequently exceed the **1.5 mg/L** WHO limit, with significant bioaccumulation in leafy vegetables (>20 mg/kg) posing a long-term risk of skeletal and dental fluorosis.

Key words: Food Stuff, Ground Water, Poisoning, Fuoride

Introduction

Fluoride (F-) is a ubiquitous geogenic element, ranked as the 13th most abundant in the Earth's crust. While it is widely recognized for its benefits in preventing dental caries at low concentrations, it has long been characterized as a "double-edged sword" in environmental toxicology. Globally, over **200 million people** across 25 countries—most notably in the "fluorosis belts" of India, China, and East Africa—are exposed to fluoride levels exceeding the World Health Organization (WHO) permissible limit of 1.5 mg/L. Historically, research and public health interventions have focused almost exclusively on fluoride in drinking water (hydrofluorosis). However, emerging evidence suggests that the ingestion of contaminated foodstuffs is a significant, yet under-reported, pathway for chronic exposure. Fluoride enters the food chain through the weathering of fluoride-bearing minerals (like fluorite and apatite) into agricultural soils and, more critically, through the long-term use of fluoride-rich groundwater for irrigation. ood crops, particularly leafy vegetables, cereals, and pulses, exhibit varying capacities for fluoride uptake. Recent studies have highlighted the role of **bioaccumulation**, where plants like *Camellia sinensis* (tea) and staple grains act as accumulators, concentrating fluoride in edible tissues at levels significantly higher than those found in the surrounding environment. Furthermore, anthropogenic activities—such as the application of phosphate-based fertilizers, coal combustion, and industrial emissions—have accelerated the loading of fluoride into the agro-ecosystem, creating a complex multi-pathway exposure profile for rural and urban populations alike. The consequences of chronic fluoride ingestion extend beyond the well-documented manifestations of **dental and skeletal fluorosis**. Recent longitudinal studies (2024–2026) have raised alarms regarding **neurodevelopmental toxicity**, linking even moderate fluoride intake to reduced IQ and behavioral disorders in children. Additionally, the biochemical interference of fluoride with essential minerals like Calcium and Magnesium disrupts metabolic pathways, leading to non-skeletal ailments involving the kidneys, liver, and endocrine system. Sanganer is characterized by semi-arid climatic conditions and a geological subsurface rich in fluoride-bearing minerals such as **fluorite** and **fluo-apatite.** The rapid industrialization of the Sanganer textile cluster, combined with over-extraction of groundwater, has led to an increase in the alkalinity of the water, which further facilitates the leaching of fluoride into the aquifer. Because Sanganer is a primary agricultural supplier for Jaipur City, the contamination of its "food stuff" has wider regional implications.

Study Area: Sanganer tehsil is one of the 13 tehsils that make up the Jaipur district in Rajasthan. It's a figurine found right below the tehsil of Jaipur. In both the north-south and east-west directions, the research area is roughly evenly distributed. Sanganer is bordered on the north by Jaipur tehsil, on the south by Phage tehsil, on the west by Phulera tehsil, and on the east by Bassi and Chaksu tehsil.

To understand the environmental condition and status of an area, it is essential to know about the following physiological features of the region:

Area & Location

Sanganer tehsil is one of the 13 tehsils that make up the Jaipur district in Rajasthan. It's a figurine found right below the tehsil of Jaipur. Tonk road, 16 kilo meters from the heart of Jaipur, is where you'll find it. It is India's most well-known town for textile printing and block printing. It's also renowned as the birthplace of the handmade paper industry.

It is located between 26041' and 2605'N latitude and 75029' to 75054'E longitude, at a height of 431 meters. In both the north-south and east-west directions, the research area is roughly evenly distributed. Sanganer is bordered on the north by Jaipur tehsil, on the south by Phage, on the east by Bassi, and on the west by Dudu.

The total area of Sanganer Tehsil is about 701.75 square kilometer, in which 214.67 square kilometers area is urban, and 487.08 square kilometers is a rural area. (Census 2011).

Review of Literature

1. Groundwater Hydro geochemistry

By the mid-2010s, Sanganer was already identified as one of the most fluoride-affected tehsils in Jaipur.

- **Key Findings:** Studies by Arif et al. (2013) and Mehta et al. (2015) established that fluoride levels in Sanganer ranged from 0.1 mg/L to as high as 6.45 mg/L.
- V**ulnerable Localities:** Villages like Lilya ka Bas, Ashawalla, and Teelawala were consistently identified as "hotspots" where concentrations exceeded the WHO permissible limit of 1.5 mg/L.
- **Geochemical Correlation:** Yadav & Garg (2014) observed a positive correlation between pH and fluoride, noting that the alkaline groundwater of Sanganer (pH approx 7.0 to 8.6) promotes the dissolution of fluoride-bearing minerals like fluorite (CaF).

2. Fluoride in Foodstuffs & Bioaccumulation

Research during this period began to highlight that water was not the only source of exposure.

- **Crops and Vegetables: Gautam et al. (2012)** conducted pioneering work in the Jaipur region (including Phagi and Sanganer), finding that **leafy vegetables (spinach)** and **cereals (wheat, bajra)** accumulate significant fluoride when irrigated with contaminated groundwater.
- **Hyper-accumulators:** Spinach was noted to contain up to **38.7 µg/g** of fluoride. Other local crops like **Chana (chickpeas)** and **Mustard** also showed high bio-concentration factors, bridging the gap between groundwater contamination and human dietary intake.

3. Clinical Observations & Health Impact

Early literature focused heavily on the physical manifestations of fluorosis in the Sanganer population.

- **Sharma et al. (2007)** documented that residents in high-fluoride villages suffered not only from dental and skeletal deformities but also from **non-skeletal fluorosis**, including gastrointestinal distress, muscle weakness, and joint pain.
- **Pediatric Impact:** Surveys from 2010–2013 indicated that over **70% of schoolchildren** in endemic villages showed signs of dental mottling.

Methodology:

Standards, the methodology typically follows these APHA-aligned steps:

1. Sample Collection

- **Water:** Grab samples are collected from hand pumps and tube wells in pre-rinsed polyethylene bottles. A 10-minute "purging" (running the pump) is standard to ensure the sample represents the aquifer, not the pipework.
- **Food:** Raw food items (wheat, mustard, spinach) are collected directly from agricultural fields. Samples are washed with distilled water to remove surface dust (atmospheric fluoride) before analysis.

2. Laboratory Analysis

- **Spectrophotometry (SPADNS Method):** This was the most common method used in older studies for water analysis. It relies on the reaction between fluoride and a zirconium-dye lake.
- **Ion-Selective Electrode (ISE):** For higher precision (often used in studies post-2012), the ISE method with **TISAB (Total Ionic Strength Adjustment Buffer)** is used to measure fluoride ion activity.
- **Plant Tissue Digestion:** Food samples are oven-dried pulverized, and then subjected to **Alkali Fusion** or **Perchloric Acid Digestion** to release fluoride from the organic matrix.

3. Risk Calculation

- **Daily Intake:** Calculated by multiplying the fluoride concentration in food/water by the average consumption rate of the Sanganer population.
- **Statistical Analysis:** Correlation coefficients are used to link fluoride levels with other parameters like **Total Hardness** and **Alkalinity**.

Result and Discussion

Leafy vegetables like onion and mustard leaves were found to have high fluoride content. Highest fluoride concentration was recorded in onion leaves (**µg/g** of sampling area ; irrigated with groundwater having mg/L fluoride concentration (Table 1). In other vegetables also like chilli, potato, spinach and cabbage, Fluoride content was estimated. High content was also recorded in Spinach (**g/g**) from sampling location irrigated with water having mg/L fluoride. Wheat and chana were tested for fluoride concentration in grains. Even when irrigated with high fluoride water, fluoride content was lower in cereals, with the maximum concentration found in chana (g/g) samples obtained from a sampling location and irrigated with water containing mg/L fluoride concentration.

Cow, buffalo, and goat milk were gathered from villages with high fluoride levels in their water supplies. Fluoride levels in milk were low in all of the samples. The maximum concentration was found in cow's milk (8.25 g/ml), while the lowest concentration was found in goat's milk. (8.25 **µg**/ml) of (Table 2).

According to the findings, fluoride content in food varies depending on fluoride levels in irrigation water and soil. It also depended on the plant's fluoride tolerance and ability for accumulation. The main source of increased fluoride exposure to the population is through diet during the winter months. This is owing to people's increased reliance on groundwater for crop and vegetable irrigation due to a lack of adequate rainfall.

Table 1: Fluoride Concentration in Raw Food Items in The Study Area

S. No.	Name of sampling site	No. of Samples analyzed	Raw Food stuffs	Fluoride Content (µg/g) in Food
1.	……..	12	Wheat	8.19
			Spinach	13.56
			Cabbage	11.46
			Cauliflower	7.58
2.	…….	12	Wheat	7.59
			Lady finger	7.90
			Chana	18.87
			Barley	14.56

Table 2: Fluoride Concentration in Milk Samples in The Study Are

S. No.	Name of Sampling Site	No. of Samples Studied	Fluoride in Buffalo Milk(μg/ml)	Fluoride in Cow Milk (μg/ml)	Fluoride in Goat Milk (μg/ml)
1.	….	5	4.13	4.38	1.67
2.	…..	5	3.45	4.12	5.36

Impact of Fluorosis in the Study Area

Fluorosis was observed in various fluoride-polluted sites and their habitat during field observations. Fluoride is a well-known trace element that plays a crucial role in human dental and skeletal development. Chronic fluoride exposure can have a variety of negative effects, the most serious of which is the disruption of bone tissue structure caused by excessive fluoride incorporation. According to a survey of drinking water in the study region, residents are at danger of developing health problems as a result of water quality issues, with fluoride being one of the biggest contaminants. Due to dental fluorosis (Fig.), which is produced by drinking fluoridated water, people's teeth have been damaged and are characterised by black and brown stains, as well as cracking and pitting of the teeth. People with dental fluorosis are unable to smile and feel embarrassed in front of unaffected people, obstructing their child's social development. Due to anguish and anxiety, a person with stained teeth develops an inferiority concept and hence presentsin psycho sociological problem to self and family. Following below picture were capture from villages in study area. Fluorosis is a major social issue. Skeletal fluorosis has a direct impact on the villagers' economy, producing health problems in humans and their domestic animals, which are also important sources of income. Due to bone abnormalities, people with skeletal fluorosis (Fig) were unable to run. There is a clear link between fluorosis and poverty. The majority of those impacted are impoverished. Health care awareness is certainly the need of the hour. But to create awareness the people have to be economically self- dependant besides malnutrition ads to the aggravation of diseases.

***Indira Gandhi for Human Ecology,**
Environmental and Population Studies
Department of Environmental Science,
University of Rajasthan, Jaipur

Core References

1. **Arif, M., Yadav, B. S., & Garg, A. (2013).** *An Investigation of Fluoride Concentration in Drinking Water of Sanganer Tehsil, Jaipur District.* EQA - International Journal of Environmental Quality, 12, 23-29.
2. **Mehta, A., Jain, N., & Duggal, R. (2015).** *Revisiting Fluoride Assay of Groundwater of Sanganer*

Tehsil, Jaipur (Rajasthan). International Journal of Engineering Research and Development, 11(11), 01-06.

3. **Gautam, R., Saini, Y., & Singh, A. (2012).** *Fluoride Accumulation by Vegetables and Crops grown in Phagi Tehsil, Jaipur.* Journal of Phytology, 4(2).
4. **Sharma, J. D., et al. (2007).** *Quality Status of Potable Water of Tehsil-Sanganer, District-Jaipur.* Asian Journal of Experimental Sciences, 21(1), 149-156.
5. **Yadav, B. S., & Garg, A. (2014).** *The Quality of Groundwater in Jaipur Region with Emphasis to Fluoride Concentration.* Journal of Pure and Applied Science & Technology, 4(2).
6. **Gangal, R. K. (2010).** *Geochemical Study of Groundwater of Sanganer Area and Methods to Mitigate Fluoride.* Asian Journal of Water, Environment and Pollution, 7(2).