

Hydrogeochemical Investigation of Fluoride Contamination in Groundwater: A Case Study of Sanganer Tehsil, Jaipur (Rajasthan)

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Abstract

Groundwater is the lifeline for the rural and peri-urban populations of Sanganer, Jaipur. However, the region is chronically affected by high concentrations of fluoride F-significantly exceeding the World Health Organization (WHO) and Bureau of Indian Standards (BIS) permissible limit of 1.5 mg/L. This paper investigates the geogenic origins of fluoride in Sanganer, identifies high-risk village clusters, and evaluates the socio-economic and health impacts on the local community based on data and studies conducted. The study emphasizes the correlation between alkaline groundwater conditions and the dissolution of fluoride-bearing minerals in the semi-arid terrain of Rajasthan.

Keywords: Fluoride, Fluorosis, Groundwater, Pollution, Skeletal Fluorosis

Introduction

Sanganer, located on the southern outskirts of Jaipur, is characterized by a semi-arid climate and a rapidly declining water table. While internationally famous for its textile printing, the region's rural hinterlands face a severe public health crisis: **Endemic Fluorosis**. Unlike anthropogenic pollutants, fluoride in Sanganer is primarily **geogenic**, leaching from the mineral-rich Aravalli bedrock into the aquifers. Several studies identified Sanganer as one of the most severely affected blocks in the Jaipur district due to the high fluoride content in its primary drinking water sources (hand pumps and borewells).

Study Area and Geological Setting

Sanganer Tehsil is an examination region situated inside the Jaipur District of Rajasthan, India. The geographic space of Jaipur locale is 11,061.44 sq km and stretches between 26° 25' north scopes. Moreover, 27° 51' and east longitude 74° 55' and 76° 15' cover the east-focal piece of Rajasthan, isolating 13 areas into tehsils and 13 squares for managerial accommodation. Sanganer Tehsil is associated with the downtown area of Jaipur. Its elevation goes from 26° 49'N to 26° 51'N. It is between 75° 46'E and 75° 51'E. Its territory is 635.5 ch. Km, the environment of this district is semi-dry and warm with power. Temperature (15–45 °C) and precipitation 650 mm (26 inches). The number of inhabitants in Sanganer Tehsil is

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Methodology

Groundwater tests (open wells/hand siphons) are gathered at the 23 towns and states from Sanganer tehsil destinations as given in Table 1. 115 water tests (5 examples for every district) were gathered in pre-purged polyethylene. 1-liter container. The examining occurred arbitrarily in July and August 2015. Water tests were shipped off the research center for investigation utilizing standard Physico-synthetic scale strategies. The estimation is resolved as fluoride (F) with the assistance of a particular particle meter (Fluoride Analysis-Fluoride focuses in water tests) dissected with the Orion Research Ion Analyzer Model 407 A, a fluoride particle specific cathode.). Common systems are followed to recognize fluoride focuses (APHA 2005). The ionic concentrate (TISAB) used to keep up adequate ionic energy and to stay away from the mind-boggling development of good outcomes.

Hydrogeochemical Analysis

Fluoride Concentration Levels

Data indicates that a vast majority of groundwater samples in Sanganer exceed the 1.5 mg/L safety threshold.

- **Critical Areas:** Villages such as **Pratap Nagar, Chimanpura, Nagaliya bhatt, and Khokabas** have levels between 1.5 mg/L to 7.0 mg/L.
- **Variation:** Concentration levels are higher in deeper aquifers compared to shallow ones, suggesting that as the water table drops, the "residence time" of water in contact with mineral-rich rocks increases.

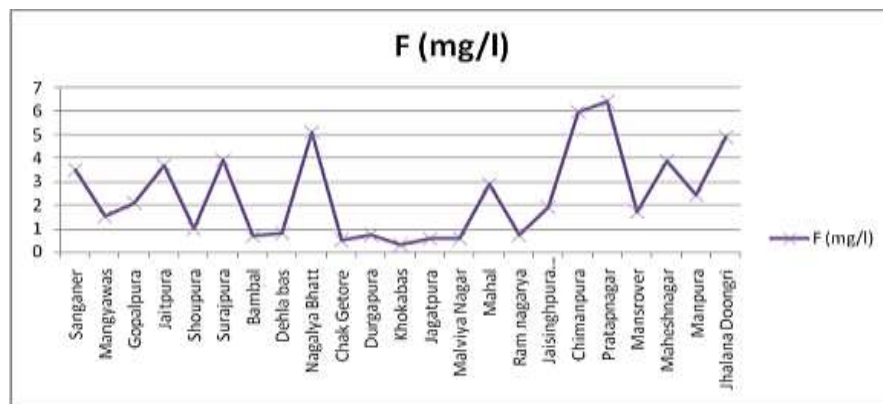


Fig : 1 . Showing fluoride of villages of Sanganer tehsil

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Factors Influencing Dissolution

The high fluoride levels are driven by specific chemical conditions:

1. **Alkalinity:** Groundwater in Sanganer is typically alkaline (pH 7.5 to 8.5). High alkalinity promotes the solubility of fluoride.
2. **Calcium Deficiency:** There is often an inverse relationship between Calcium and Fluoride. Low calcium levels prevent the precipitation of fluoride as Calcium fluoride keeping it dissolved in the water.

Impacts on Human Health

The prolonged consumption of this water has led to permanent physiological damage in the local population:

- **Dental Fluorosis:** Highly prevalent among children in Sanganer, manifesting as "mottled enamel," pitting, and brown staining of teeth.
- **Skeletal Fluorosis:** A debilitating condition found in the adult population, leading to the calcification of ligaments, joint pain, and "knock-knees" (Genu valgum).
- **Non-Skeletal Effects:** Studies prior to 2022 also suggested correlations between high fluoride intake and gastrointestinal issues as well as impaired thyroid function in the region.
- **Mitigation Strategies** several interventions were proposed and partially implemented:
- **Nalgonda Technique:** A community-level defluorination method using alum and lime.
- **Defluorination Filters:** Distribution of domestic-grade activated alumina filters.
- **Surface Water Shift:** The gradual transition to using surface water from the **Bisalpur Dam** to replace contaminated groundwater.

Summary and Conclusion

The fluoride crisis in Sanganer is a natural geological phenomenon exacerbated by excessive groundwater extraction. Historical data confirms that without significant shifts toward surface water and rainwater harvesting, the rural population remains at high risk of permanent physical disability.

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