

Hydrogeochemical Assessment of Fluoride Contamination in Sanganer and Its Impact on Seed Germination and Initial Growth Phases

***Dr. Surendra Singh Chauhan**

Abstract

Fluoride (F-) contamination in groundwater is a persistent geogenic challenge in the semi-arid regions of Rajasthan. While the clinical effects of fluorosis on human health are well-documented, the impact of fluoride-rich irrigation water on the early developmental stages of crops is equally critical for regional food security. This paper investigates the fluoride levels in the villages of Sanganer, Jaipur, and evaluates how these concentrations influence the germination percentage and seedling vigor of local crops. Reviewing literature prior to 2023, the study finds a significant inverse relationship between fluoride concentration and seed metabolic efficiency.

Key words: Germination, Fluoride, Pollution, Sanganer

Introduction

Ecological contamination by fluoride can have serious ramifications for life forms, vegetation, and fauna because of water, soil, air, or a combination of each of the three mankind. The matter of high fluoride inside the climate in India and in this manner the subsequent wellbeing risks have been uncovered. The size of the worth is important to investigate factors like the wellspring of fluoride, the topographical appropriation of fluoride, and its scattering [Rajesh Kumar Yadav et al. 2012]. Soil and water assets are being dirtied on account of different natural elements like unsafe squanders, fluid and soil squanders from businesses, removal, surface hindrances, and so on By and large, water assets are undependable for human utilization, yet in addition for different exercises related with water system and mechanical requirements. The presence of fluoride in high fixations in food and water turned into an overall concern. Around 200 million individuals from 25 nations experience the ill effects of the staggering impacts of fluorosis [Malti Rotwar et al. 2020] Sanganer, located on the southern fringe of Jaipur, is a region under severe hydrological stress. With groundwater serving as the primary source for both domestic use and irrigation, the presence of high fluoride levels leaching from the granitic and gneissic rocks of the Aravalli Supergroup has created an environmental bottleneck. For farmers, the quality of irrigation water is paramount; however, high Fluoride (F-) concentrations act as a metabolic inhibitor during the critical window of seed germination and early plumule-radicle development.

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Study Area: Sanganer Tehsil

The study area encompasses the Sanganer block of Jaipur district.

- **Geography:** Situated at approximately 26.8135° N, latitude and 75.7849° E longitude.
- **Geology:** The terrain is characterized by alluvium and wind-blown sand, underlain by Precambrian rocks containing fluoride-bearing minerals like fluorite and apatite.
- **Hydrology:** The region is classified as a "Dark Zone" due to over-exploitation of groundwater.

Review of Literature**Groundwater Fluoride Status**

Studies by **Dutta et al. (2019)** and **Kumar & Sharma (2014)** have consistently reported fluoride levels in Sanganer villages—such as **Vatika, Lakhna, and Balawala**—ranging from Fluoride F-2.5 mg/L to over Fluoride (F-) 7.0 mg/L, far exceeding the BIS permissible limit of Fluoride (F-) 1.0–1.5 mg/L.

Impact on Seed Germination

Research indicates that fluoride is a protoplasmic poison. **Sharma et al. (2021)** demonstrated that in wheat and mustard crops, an increase in Fluoride (F-) concentration leads to a significant reduction in the germination percentage. Fluoride inhibits the activity of the enzyme **alpha -amylase**, which is essential for breaking down starch into sugars to provide energy for the growing embryo.

Impact on Growth and Germination**Seed Germination Percentage**

Fluoride enters the seed coat through imbibition. At concentrations found in Sanganer's groundwater (F- 3 mg/L), the following effects are observed:

- **Delayed Germination:** The time taken for the first radicle appearance increases.
- **Reduction in Percentage:** In highly contaminated samples (F- >5 mg/L), germination rates can drop by 30 % to 50 %
- Drinking water parameter given by the WHO,USPH BIS (Table-1)

Seedling Vigor and Early Growth

The early growth of the seedling is hampered by the translocation of fluoride from the roots to the shoot.

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- **Radicle and Plumule Length:** High Fluoride (F-) levels inhibit cell division in the apical meristem. Studies on local pulses and cereals show that radicle (root) growth is more sensitive to fluoride than plumule (shoot) growth.
- **Biomass Reduction:** Seedlings grown in Sanganer's groundwater show lower fresh and dry weights due to reduced nutrient uptake and water stress induced by high mineral salinity.

Physiological Disruptions

1. **Enzyme Inhibition:** Fluoride (F-) ions bind with metal activators (like Ca⁺² and Mg⁺² required for enzyme function, halting the mobilization of food reserves.
2. **Oxidative Stress:** Fluoride induces the production of Reactive Oxygen Species (ROS), leading to lipid peroxidation and damage to the cell membranes of the germinating seed.

Summary and Conclusion

The groundwater of Sanganer is not only a threat to human health but also a silent inhibitor of agricultural productivity. The high fluoride levels significantly hinder the germination and early growth of staple crops. To mitigate this, the study recommends the use of calcium-rich soil amendments (like gypsum) to precipitate fluoride and the adoption of rainwater harvesting to dilute the concentration of (F-) in the aquifers.

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Table 1: Drinking Water Parameter is given by WHO, APHA, BIS

Parameter	USPH standard	WHO standard	BSI standard
Color	Colorless	-	5
Odor	Odorless	-	Unobjectionable
Taste	Tasteless	-	Agreeable
pH	6.0-8.5	6.5-9.2	6.5-8.5
DO	4.0-6.0	-	3.0
TDS	500	500	500
TSS			100
Cl	250	500	250
SO ₄	250	200	200
NO ₃	<10	45	45
so ₄ ⁻	-	-	400
F	1.5	0.5	1.0
PO ₄	0.1		-
Ca	100	100	75

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