

Impact of Textile Effluent Irrigation on the Physiological and Biochemical Profile of Vegetables in Sanganer, Jaipur

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Abstract

This paper investigates the environmental consequences of utilizing untreated textile industry effluent for vegetable irrigation in Sanganer, Jaipur. Sanganer is a global center for hand-block printing, but its lack of integrated waste management has led to the heavy contamination of the Drawyati River (Amani shah Nalla). Research conducted prior to 2023 indicates that irrigation with this effluent significantly alters the physiological growth and biochemical constituents of vegetables such as *Spinacia oleracea* (Spinach), *Brassica oleracea* (Cauliflower), and *Raphanus sativus* (Radish). The findings highlight inhibited germination, reduced chlorophyll content, and alarming levels of heavy metal bioaccumulation (Cr,Pb,Cd,Zn), rendering these food sources a significant health risk.

Key words : Heavy Metal, Textile effluent, Water Pollution, Biochemical Profile

Introduction

Clean water is one of the most crucial concerns facing both the developed and developing worlds. Groundwater is an essential component of life on Earth and a source of survival. Wastewater treatment is a significant environmental barrier to the growth of the textile industry, in addition to other secondary issues including solid waste and resource waste management. The world's largest industrial sector, the textile industry is crucial to the growth of any nation's economy. Despite this, the business produces a lot of chemicals, including wastewater that contains dyes. The textile sector is the one that uses the most fresh water while also releasing a significant amount of pollution into the environment. Throughout its various production processes, the textile sector produces the most wastewater. Wastewater causes a number of issues, including water contamination, aquatic life, and health issues.

The textile industry in Sanganer involves intensive dyeing and printing processes that utilize a complex array of chemicals, including azo dyes, mordants, and heavy metals. Due to water scarcity in Rajasthan, farmers in the peri-urban areas of Jaipur frequently divert the untreated industrial runoff from the Amani shah Nalla to their fields. This wastewater serves as a double-edged sword: while it provides water and some organic matter, it introduces persistent pollutants into the soil-plant system.

Characterization of Sanganer Textile Effluent

Studies conducted on the Sanganer industrial clusters show that the effluent is highly alkaline and

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loaded with dissolved solids and toxic metals.

Table 1: Physico-chemical Analysis of Textile Effluent in Sanganer

Parameter	Textile Effluent (Sanganer)	BIS Standards (Irrigation)
pH	9.2 – 10.5	6.5 – 8.5
TDS (mg/L)	3500 – 5200	2100
BOD (mg/L)	450 – 900	100
COD (mg/L)	1200 – 2400	250
Chromium (mg/L)	3.2 – 5.8	0.1
Lead (mg/L)	1.5 – 2.1	0.1

Impact on Physiological Profile

The physiological response of vegetables to textile effluent is dose-dependent. While highly diluted effluent (10–20%) may slightly stimulate growth due to nitrogenous compounds, higher concentrations are detrimental.

Seed Germination and Morphological Growth

Research on *Vicia faba* and *Phaseolus aureus* in the Jaipur region has shown that effluent concentrations exceeding 25% significantly delay and inhibit germination. This is primarily due to the **high osmotic pressure** of the wastewater, which prevents the seeds from absorbing the water necessary for metabolic activation.

- **Root/Shoot Length:** Significant reduction in length is observed at 100% effluent concentration due to the toxicity of heavy metals like Chromium (Cr), which interferes with cell division in the apical meristems.

Biomass Production

The fresh and dry weight of vegetables irrigated with Sanganer effluent shows a downward trend as the concentration of effluent increases.

Study Area :

Sanganer is located approximately 15 km south of Jaipur. It serves as a major hub for the textile industry, but the local ecology is defined by the following factors:

- **The Amani shah Nala:** This seasonal stream acts as the primary drainage channel for the city. It receives a massive volume of industrial effluent—rich in synthetic dyes, fixing agents, and heavy metals—which is then used for "peri-urban" agriculture.
- **Soil Composition:** The soil in this region is generally sandy to sandy-loam. Because it is highly permeable, the toxic heavy metals from the effluent easily leach into the root zones of plants.

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- **Common Crops:** The area primarily produces seasonal vegetables like **Spinach (*Spinacia oleracea*)**, **Radish (*Raphanus sativus*)**, **Cabbage**, and **Cauliflower**, which are eventually sold in Jaipur's local markets.

Impact on Biochemical Profile

The biochemical integrity of the vegetables is the most severely affected aspect, often invisible to the naked eye until the damage is advanced.

Photosynthetic Pigments

Heavy metals from the dyes (specifically Cu, Zn, and Cr) interfere with chlorophyll synthesis. Cr ions can replace the Mg²⁺ ion in the porphyrin ring of the chlorophyll molecule, leading to "Heavy Metal Substituted Chlorophylls," which are ineffective at photosynthesis.

Table 2: Chlorophyll Content in *Spinacia oleracea* (Spinach) grown in Sanganer

Treatment	Total Chlorophyll (mg/g FW)	% Reduction
Control (Tap Water)	1.85	0%
50% Effluent	1.12	39.5%
100% Effluent	0.64	65.4%

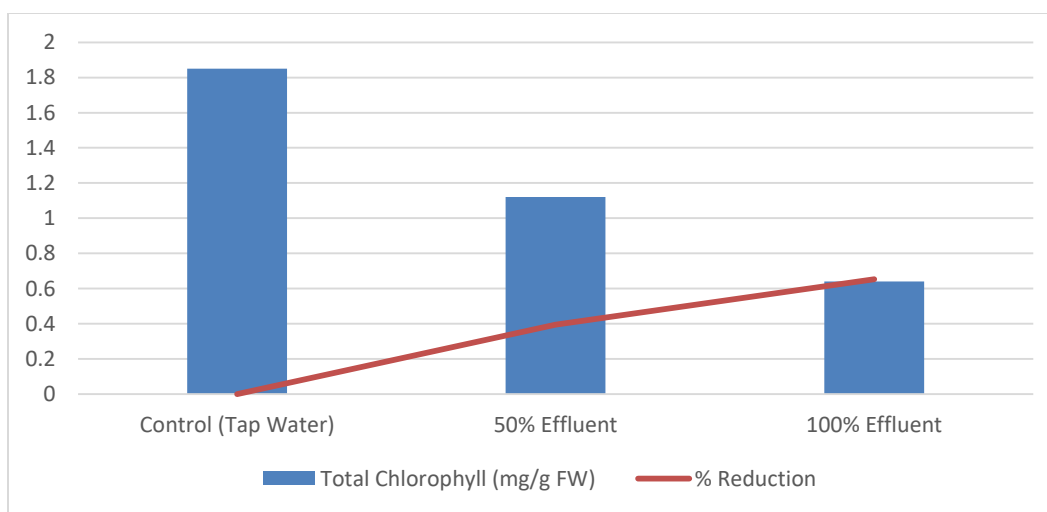


Fig 2: Chlorophyll Content in *Spinacia oleracea* (Spinach) grown in Sanganer

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Oxidative Stress and Enzyme Activity

Plants exposed to Sanganer effluent exhibit a "stress-response" biochemical profile. There is a marked increase in **Proline** content—an amino acid that acts as an osmoprotectant—and an up-regulation of antioxidant enzymes like **Superoxide Dismutase (SOD)** and **Catalase (CAT)** to combat Reactive Oxygen Species (ROS).

Heavy Metal Bioaccumulation

The most critical finding is the Bio-Concentration Factor (BCF). Vegetables in Sanganer accumulate metals far beyond the permissible limits for human consumption.

Table 3: Heavy Metal Concentration in Edible Parts of Vegetables (mg/kg)

Vegetable	Chromium (Cr)	Lead (Pb)	Cadmium (Cd)
Spinach	12.4	4.8	1.2
Radish	8.6	3.2	0.8
Cauliflower	10.1	3.9	1.0
WHO Limit	0.1	0.3	0.2

Summary and Conclusion

The irrigation of vegetables with textile effluent in Sanganer, Jaipur, represents a significant environmental health crisis. The physiological data confirms stunted growth and reduced yields, while biochemical analysis reveals a dangerous accumulation of heavy metals and a breakdown of photosynthetic mechanisms. These vegetables, sold in the local markets of Jaipur, pose long-term risks of chronic metal poisoning to the consumers.

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