

Effect of Textile Dye Industry Waste Residues: An Examination into the Evolution, Biochemical Characteristics**Effect of Textile Dye Industry Waste Residues:
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ABSTRACT:

Industrial effluents are increasingly being explored for agricultural reuse due to their nutrient content, despite potential toxicity risks. The present study evaluates the influence of varying concentrations of dyeing industry effluent residue on the growth performance, biochemical parameters, and yield of brinjal (*Solanum melongena*).

A pot culture experiment was conducted over a period of 90 days using graded doses of effluent residue ranging from 0 mg (control) to 1200 mg. Results indicated that lower concentrations (200–600 mg) enhanced germination, growth, and biochemical constituents such as chlorophyll, carotenoids, and proteins.

However, higher concentrations (≥ 1000 mg) exhibited inhibitory effects due to toxicity, leading to reduced growth and absence of fruit formation. The study concludes that controlled application of effluent residue can be beneficial, but excessive accumulation adversely affects plant health and productivity.

Keywords: Dyeing effluent, Brinjal, Growth parameters, Biochemical characteristics, Heavy metals, Agricultural reuse.

INTRODUCTION:

Environmental pollution arising from rapid industrialization has become a global concern. Among various pollutants, industrial effluents represent a significant source of contamination affecting soil and water systems.

However, these effluents often contain essential nutrients and trace elements that may support plant growth when applied in controlled quantities.

Dyeing industry effluents, in particular, are known to contain heavy metals, organic compounds, and inorganic salts. While excessive levels of these substances are toxic, lower concentrations may act as micronutrients, thereby promoting plant development. The reuse of such effluents in agriculture has been proposed as a sustainable approach to waste management and resource recycling.

Brinjal (*Solanum melongena*), an economically important vegetable crop, is widely cultivated and sensitive to soil conditions. Despite several studies on industrial effluents, limited research has focused on the impact of dyeing industry effluent residue on brinjal growth and productivity. Therefore, the present study aims to

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systematically investigate the effects of varying levels of effluent residue on growth, biochemical responses, and yield of brinjal.

AIM AND OBJECTIVES

Aim

To evaluate the impact of dyeing industry effluent residue on growth, biochemical characteristics, and yield of *Solanum melongena*.

Objectives

- To assess the effect of effluent residue on seed germination and plant growth parameters.
- To analyze biochemical changes in response to effluent treatment.
- To evaluate the influence of effluent residue on yield attributes.
- To determine the optimal concentration for beneficial effects without toxicity

MATERIALS AND METHODS

Collection of Effluent

Effluent samples were collected from a dyeing industry located in Dindigul, Tamil Nadu, India. The samples were transported to the laboratory in sterile containers for further analysis and processing.

Experimental Design

A pot culture experiment was conducted using plastic pots filled with a mixture of red soil, sand,

and cow dung in a 1:1:1 ratio. Seven treatment groups were established:

- T0 – Control (no effluent residue)
- T1 – 200 mg residue
- T2 – 400 mg residue
- T3 – 600 mg residue
- T4 – 800 mg residue
- T5 – 1000 mg residue
- T6 – 1200 mg residue

Each treatment was replicated, and plants were grown under natural environmental conditions.

Seed Germination and Growth Analysis

Brinjal seeds were soaked in water prior to sowing. Germination percentage, shoot length, root length, leaf area index, fresh weight, dry weight, and vigor index were recorded at regular intervals over 90 days.

Biochemical Analysis

Biochemical parameters were estimated using standard procedures:

- Chlorophyll a, b, and total chlorophyll
- Carotenoids and anthocyanin
- Total soluble sugars
- Protein content
- Free amino acids
- L-proline
- Leaf nitrate content
- Nitrate reductase activity
- Catalase activity

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Yield Parameters

Yield attributes such as number of fruits, fruit weight, and fruit length were recorded at harvest.

RESULTS AND DISCUSSION

Growth Parameters

Seed germination was highest in lower concentrations, particularly in T1 (200 mg), indicating that minimal levels of effluent residue can enhance germination. However, higher concentrations resulted in reduced germination due to toxicity effects.

Plant growth parameters such as shoot and root length showed a similar trend. Optimal growth was observed at lower to moderate concentrations (T1–T3), while higher concentrations (T5–T6) significantly inhibited growth. This reduction may be attributed to decreased oxygen availability and accumulation of toxic substances affecting metabolic processes.

Leaf area index and vigor index also declined at higher concentrations, suggesting that excessive effluent residue interferes with cellular expansion and physiological efficiency.

Biochemical Characteristics

Biochemical analysis revealed that chlorophyll content was highest in T3 (600 mg), indicating enhanced photosynthetic activity at moderate concentrations. However, at higher concentrations, chlorophyll levels declined, likely

due to pigment degradation caused by heavy metal stress.

Carotenoids and anthocyanin levels followed a similar pattern, reflecting stress adaptation mechanisms in plants. Increased anthocyanin accumulation at higher concentrations suggests a protective response against oxidative stress.

Total soluble sugars and protein content were higher in moderate treatments, indicating improved metabolic activity. In contrast, elevated levels of free amino acids and proline in higher treatments suggest stress-induced metabolic adjustments.

Enzymatic activities such as nitrate reductase and catalase showed variable responses, with reduced activity at higher concentrations due to enzyme inhibition by toxic compounds.

Yield Attributes

Yield performance was significantly affected by effluent residue concentration. Fruit production was observed only in control and lower treatments (T0–T2). Although flowering occurred in higher treatments, fruit formation was absent due to toxicity.

Fruit weight and length were highest in control plants and decreased progressively with increasing effluent concentration. This indicates that while low levels may support growth, higher levels impair reproductive development.

Effect of Textile Dye Industry Waste Residues: An Examination into the Evolution, Biochemical Characteristics**CONCLUSION**

The present study demonstrates that dyeing industry effluent residue has both beneficial and detrimental effects on brinjal cultivation, depending on its concentration. Lower concentrations (200–600 mg) promote growth, enhance biochemical constituents, and support yield. However, higher concentrations (≥ 1000 mg) exhibit toxic effects, leading to reduced growth and complete inhibition of fruit production.

Thus, controlled and judicious use of industrial effluent residue can serve as an alternative nutrient source in agriculture. However, strict monitoring is essential to prevent environmental and crop damage

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