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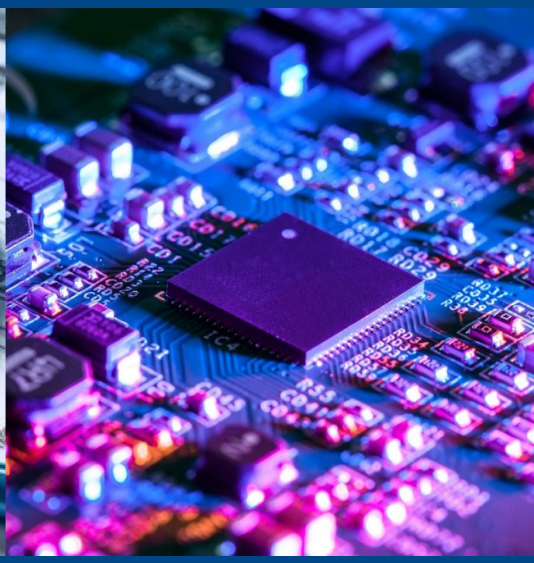

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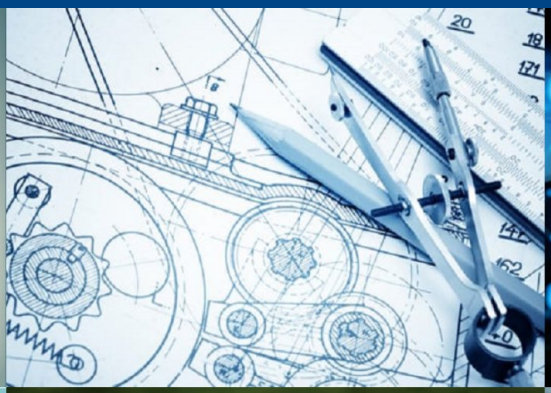

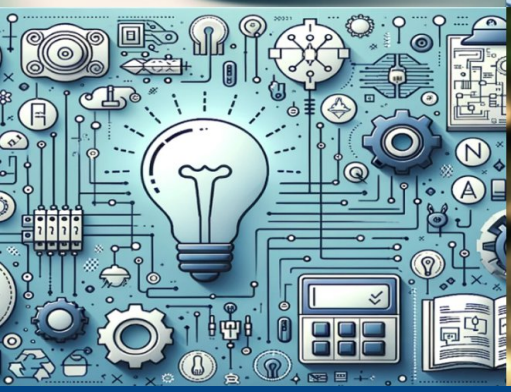

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Effects of Vanaspathi Industrial Effluent on Growth Parameters of *Raphanus sativus L.* Under Controlled Conditions

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ABSTRACT: Industrial wastewater reuse in agriculture is increasing due to freshwater scarcity, particularly in rapidly urbanizing regions. However, industrial effluents may exert both beneficial and toxic effects on crop plants depending on their composition and concentration. The present study evaluated the effects of vanaspathi industrial effluent on growth parameters of radish (*Raphanus sativus L.*) under greenhouse conditions. Effluent dilutions of 0%, 10%, 25%, 50%, and 75% were applied, and growth responses were assessed. Moderate effluent concentrations (25–50%) significantly enhanced growth, whereas higher concentration (75%) caused growth inhibition, indicating phytotoxicity beyond optimal dilution thresholds. The results highlight the dual role of industrial effluents as nutrient sources at low concentrations and stress-inducing agents at higher levels.

I. INTRODUCTION

Industrialization has resulted in extensive utilization of water resources and increased discharge of wastewater containing organic and inorganic contaminants. According to **Tchobanoglous et al. (2014)**, industrial wastewater often contains dissolved solids, organic compounds, and trace elements that can influence soil and plant systems. The indiscriminate disposal of industrial effluents into the environment has led to significant ecological concerns, including soil degradation and groundwater contamination, as reported by **Alloway (2013)**.

In many developing regions, wastewater irrigation has become a common practice due to freshwater shortages. Studies by **Qadir et al. (2010)** and **Toze (2006)** demonstrated thatwastewater irrigation can provide essential nutrients but may also introduce toxic compounds affecting plant growth and metabolism. The response of plants to industrial effluents is often concentration-dependent, where low levels may stimulate growth while higher levels induce stress conditions.

Vanaspathi industry effluent generated during vegetable oil processing contains organic residues and mineral components that may influence plant physiology. Radish (*Raphanus sativus L.*), a fast-growing root crop sensitive to environmental stress, has been widely used as a model species for evaluating wastewater toxicity and nutrient response (**Dias et al., 2011**).

II. MATERIALS AND METHODS

Effluent Collection and Experimental Setup

Vanaspathi industrial effluent was collected from vegetable oil processing units and diluted to obtain concentrations of 10%, 25%, 50%, and 75%. Control plants received tap water only. Plants were grown under greenhouse conditions with uniform environmental parameters.

Growth Measurements

Growth parameters such as root length, fresh and dry biomass, and leaf area were recorded. All values were expressed as Mean ± Standard Error (SE).

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III. RESULTS

Table 1. Effect of Vanaspathi Industrial Effluent on Growth Parameters of *Raphanus sativus L.*

Sl. No	Effluent Concentration	Root Length (cm)	Root Fresh Wt (g)	Root Dry Wt (g)	Leaf Area (sq.cm)	Leaf Fresh Wt (g)	Leaf Dry Wt (g)
1	0% (Control)	8.0 ± 0.24	250.0 ± 5.50	10.0 ± 1.63	351 ± 7.70	210.0 ± 2.09	14.8 ± 0.36
2	10%	8.2 ± 0.70	268.5 ± 2.09	10.5 ± 0.48	400 ± 9.30	251.3 ± 1.27	15.2 ± 0.12
3	25%	12.0 ± 0.33	370.2 ± 5.28	15.5 ± 1.00	505 ± 6.20	330.2 ± 3.46	20.3 ± 0.61
4	50%	12.1 ± 0.22	390.5 ± 2.09	16.4 ± 0.14	570 ± 7.50	360.3 ± 1.73	22.5 ± 0.17
5	75%	8.5 ± 0.48	175.0 ± 2.09	8.3 ± 0.86	289 ± 6.20	170.3 ± 2.40	11.3 ± 0.24

Values are Mean ± Standard Error (SE).

Effect of Effluent Concentration on Plant Growth

Growth responses of radish plants exposed to different concentrations of vanaspathi industrial effluent showed a concentration-dependent pattern (Table 1). Moderate effluent concentrations (25% and 50%) significantly enhanced growth compared to control plants.

Root length increased from 8.0 cm in control plants to 12.1 cm at 50% effluent concentration. Similarly, root biomass and leaf area exhibited substantial enhancement, indicating improved physiological performance.However, plants treated with 75% effluent showed reduced growth, suggesting phytotoxic effects associated with excessive pollutant exposure.

IV. DISCUSSION

The growth stimulation observed at moderate effluent concentrations may be attributed to increased availability of organic nutrients and micronutrients, which enhance plant metabolism and biomass accumulation. Similar findings were reported by **Rattan et al. (2005)** and **Singh and Agrawal (2012)**, who demonstrated growth promotion in crops irrigated with diluted wastewater.

Enhanced leaf area suggests improved photosynthetic activity, while increased root development indicates enhanced nutrient uptake efficiency. However, higher effluent concentration likely introduced osmotic stress or toxic compounds, resulting in growth inhibition.

High levels of industrial contaminants can induce oxidative stress through overproduction of reactive oxygen species (ROS), as described by **Mittler (2002)** and **Gill and Tuteja (2010)**. Oxidative stress disrupts cellular metabolism and reduces plant growth, which explains the reduced performance at higher effluent concentration. Studies by **Hasanuzzaman et al. (2011)** further confirmed that excessive environmental stress leads to decreased biomass accumulation and physiological impairment.

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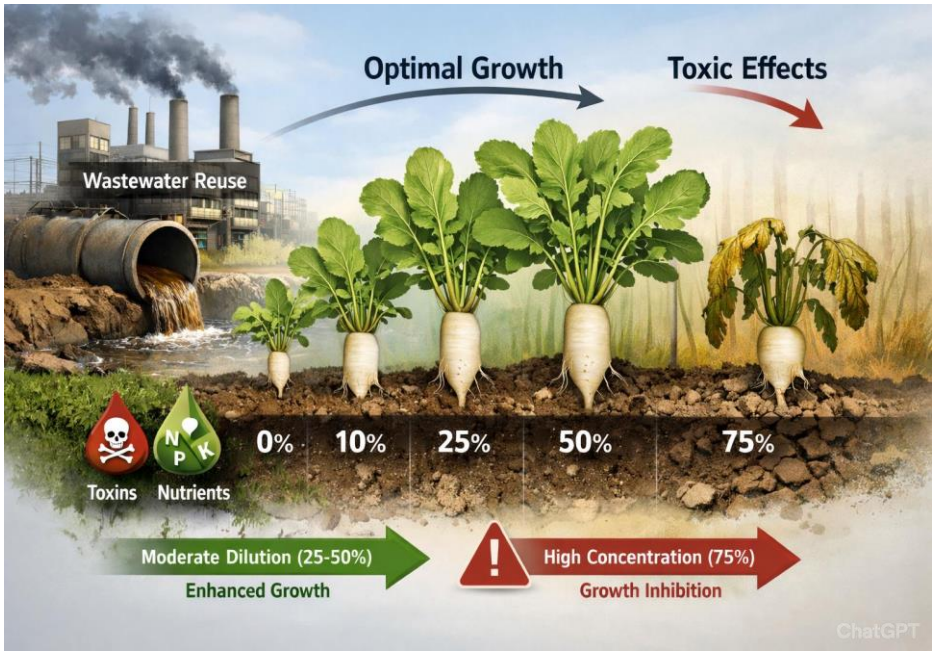

V. CONCLUSION

The present investigation demonstrates that vanaspathi industrial effluent has a concentration- dependent effect on growth of *Raphanus sativus L.* Moderate dilutions (25–50%) enhanced growth parameters, whereas higher concentration (75%) induced phytotoxic effects. Controlled application of diluted industrial effluents may support sustainable agriculture; however, proper monitoring is essential to avoid ecological risks.

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