SUSTAINABLE PHOTOCATALYTIC TREATMENT OF HOSPITAL WASTEWATER USING GREEN SYNTHESIS OF TiO2 NANOPARTICLES FROM GUAVA LEAF EXTRACT

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ABSTRACT

Environmental safety is a pressing global concern, with water pollution being a particularly critical issue. Hospital wastewater is a major source of pollution due to its complex composition, including pharmaceuticals, pathogens, and heavy metals. This study investigates the sustainable photocatalytic treatment of such wastewater using green synthesized TiO_2 nanoparticles derived from guava leaf extract. The objectives included analyzing the properties of both the nanoparticles and raw wastewater, determining optimal treatment conditions, and comparing the efficiency of this method with conventional techniques. Results demonstrated that green synthesized TiO_2 nanoparticles significantly reduce pollutants, showcasing their potential as an eco-friendly and effective treatment alternative

INTRODUCTION

Water pollution is a growing global concern, particularly with the increasing discharge of untreated or partially treated hospital wastewater. Such effluents contain complex contaminants, including pharmaceuticals, pathogens, heavy metals, and organic compounds, which pose severe threats to both environmental and human health.

Traditional wastewater treatment methods often fall short in effectively removing these pollutants. Advanced treatment technologies are thus essential to meet stricter regulatory and environmental standards.

Nanotechnology offers a promising solution, particularly through the use of titanium dioxide (TiO_2) nanoparticles, known for their high surface area, photocatalytic properties, and chemical stability. However, conventional synthesis of TiO_2 involves toxic chemicals and energy-intensive processes, raising sustainability concerns.

This study addresses these limitations by utilizing a **green synthesis approach**, using **guava leaf extract** as a natural reducing and stabilizing agent. The eco-friendly TiO_2 nanoparticles are then applied in a **combined adsorption and photocatalytic treatment process** for hospital wastewater. The objective is to evaluate the effectiveness and feasibility of this sustainable method in real-world conditions.
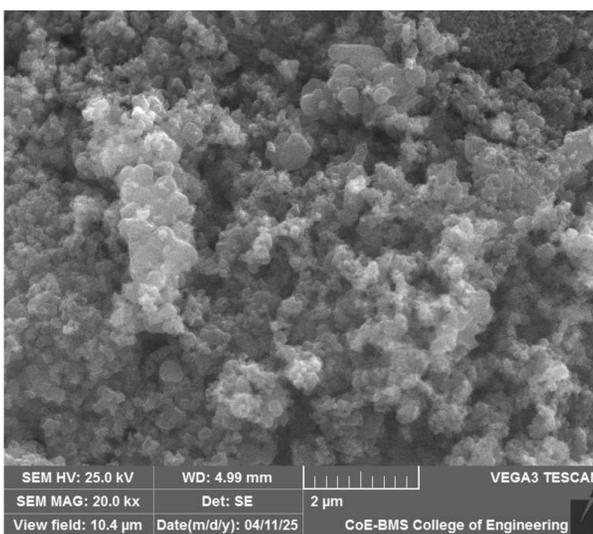
MATERIALS

Preparation of Nano-Particle from Guava Leaf Extract

Nano-Material

Guava leaves were dried, powdered, and boiled to extract phytochemicals. The extract was mixed with Titanium Isopropoxide (TTIP) and stirred for 8 hours. Resulting solution was centrifuged, dried, and calcined at 570°C to obtain nanoparticles.

SEM Analysis

The particles exhibit an irregular morphology, with some appearing rod-like or flake-like in shape. The surface texture is rough and layered. The material possesses a very high surface area, attributed to its thin structure and broad faces. It exhibits a high adsorption capacity. It particularly effective for the removal of dyes, surfactants, and pharmaceutical residues from various media

METHODOLOGY

Nano-adsorbent Treatment: varying doses ranging from 0.1 g to 0.9 g of TiO_2 was added to 500 mL of hospital wastewater and agitated on an orbital shaker for contact time of 1 hour.


Photocatalytic Treatment: Collected sample after Nano-adsorbent treatment (500 mL) without altering the pH was treated photo catalytically using the green TiO2 NPs (Optimum Dosage of 0.7 g) for 30 minutes in a self-designed and fabricated photo catalytic reactor.


REACTOR
UV BULB
WASTEWATER SAMPLE

RESULTS

PARAMETER	RAW WASTEWATER
pH	6.7
Turbidity	84 NTU
COD	1900mg/L

Nano-adsorbent Treatment:
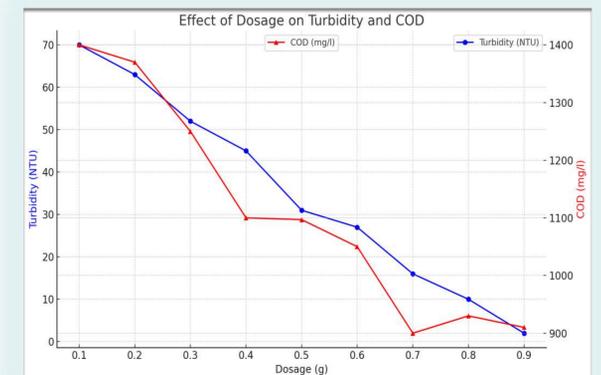
Turbidity decreases sharply as dosage increases, indicating effective particle removal. **COD** also decreases with increasing dosage, showing organic load reduction, although there's a slight rise beyond 0.7g, suggesting optimal dosage of **0.7g**.

Photocatalytic Treatment
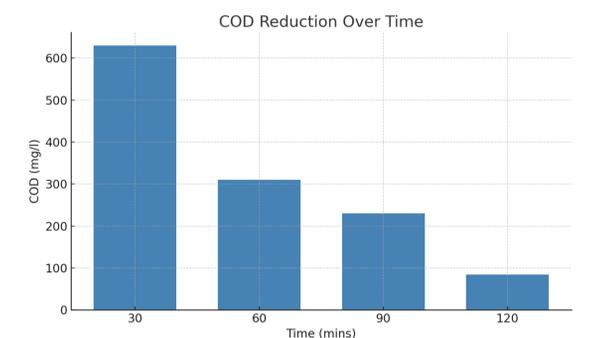
COD levels dropped significantly from 630 mg/L at 30 minutes to just 84 mg/L at 120 minutes. This indicates effective organic pollutant removal efficiency using nanomaterials over extended contact time.

PARAMETER	TREATED WASTEWATER
pH	7.2
Turbidity	2 NTU
COD	84 mg/L

CONCLUSION

The study demonstrates that green-synthesized TiO_2 nanoparticles using guava leaf extract are highly effective in treating hospital wastewater. Nano-adsorbent and photocatalytic treatments significantly reduced turbidity and COD levels, with optimum performance observed at a dosage of 0.7 g/L. COD levels reduced from 1000 mg/L to 84 mg/L, and turbidity dropped to 2 NTU, indicating excellent pollutant removal efficiency. This eco-friendly, sustainable approach offers a promising alternative for advanced wastewater treatment, particularly in medical and pharmaceutical effluent management