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

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Introduction:

The growing concern over hospital wastewater management is driven by the increasing volume of harmful pollutants and chemicals that such waste contains, which poses serious risks to human health and the environment. Among the many contaminants in hospital effluents, pharmaceuticals, heavy metals, and pathogens are particularly worrisome. Traditional treatment methods often fall short in addressing these complex pollutants, highlighting the need for more sustainable and efficient alternatives.

One promising solution is the use of photocatalytic treatment, a process that utilizes photocatalysts like Titanium Dioxide (TiO2) nanoparticles to degrade organic pollutants under light irradiation. However, the conventional synthesis of TiO2 nanoparticles can involve toxic chemicals and high-energy processes, making it less environmentally friendly.

To overcome this challenge, green synthesis methods using natural plant extracts have gained attention. Guava leaf extract, rich in bioactive compounds, has demonstrated the ability to reduce metal ions into nanoparticles in an eco-friendly manner. By utilizing guava leaf extract in the synthesis of TiO2 nanoparticles, this

research explores a sustainable approach to hospital wastewater treatment. The goal is to enhance the photocatalytic degradation of pollutants, thus providing a more effective and environmentally conscious method for purifying hospital wastewater.

Objectives:

MAJOR OBJECTIVE:

- To investigate the effectiveness and stability of the green synthesized tio2 Nanoparticles in treating hospital wastewater.

SPECIFIC OBJECTIVES:

- To analyse the physical and chemical properties of green synthesized tio2 nanoparticles and Raw hospital wastewater
- To determine the optimal conditions for the photo catalytic treatment under various conditions
- To compare the photo catalytic treatment efficiency of green synthesized tio2 Nanoparticle with the existing conventional treatment methods.

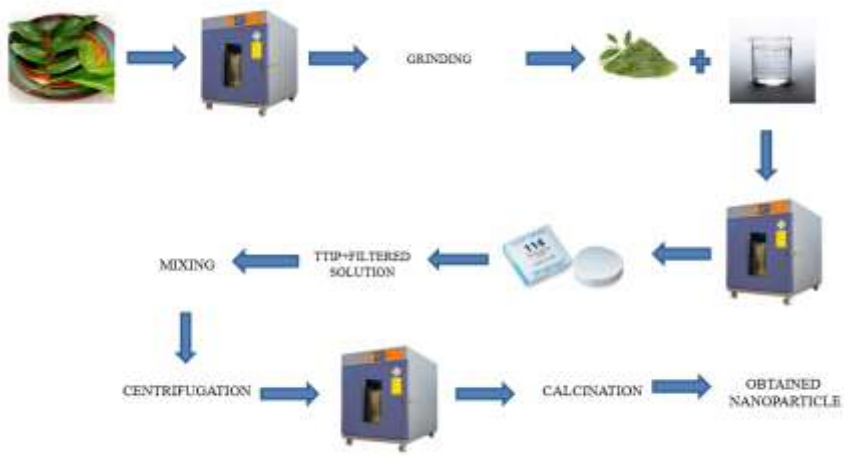
Methodology:

Characterization of Hospital Wastewater:

The wastewater sample for this study was collected from the Hassan Institution of Medical Sciences, located within the Sri Chamarajendra Hospital Campus, Hassan, Karnataka. The hospital generates significant wastewater containing pharmaceutical residues, pathogens, disinfectants, and heavy metals. Raw wastewater analysis of the sample examined key parameters, including turbidity, pH, and Chemical Oxygen Demand (COD), to assess wastewater quality. Turbidity measures suspended particles, pH indicates acidity or alkalinity, and COD evaluates the pollution level. This analysis helps inform treatment strategies for hospital wastewater.

Green synthesis of TiO2 Nanoparticles:

Titanium-isopropoxide was used to synthesize TiO2 nanoparticles, with guava leaves acting as a bio-template. The leaves were washed, dried, ground into powder, and mixed with distilled water to prepare an extract, which acted as a stabilizing agent for the synthesis. TiO2 nanoparticles were formed by adding 5 MM TiO2 precursor to the leaf extract and stirring for 8 hours. The mixture was then centrifuged, and the resulting nanoparticles were dried and calcined at 570°C. The synthesized TiO2 nanoparticles were stored for further characterization and photocatalytic wastewater treatment studies.



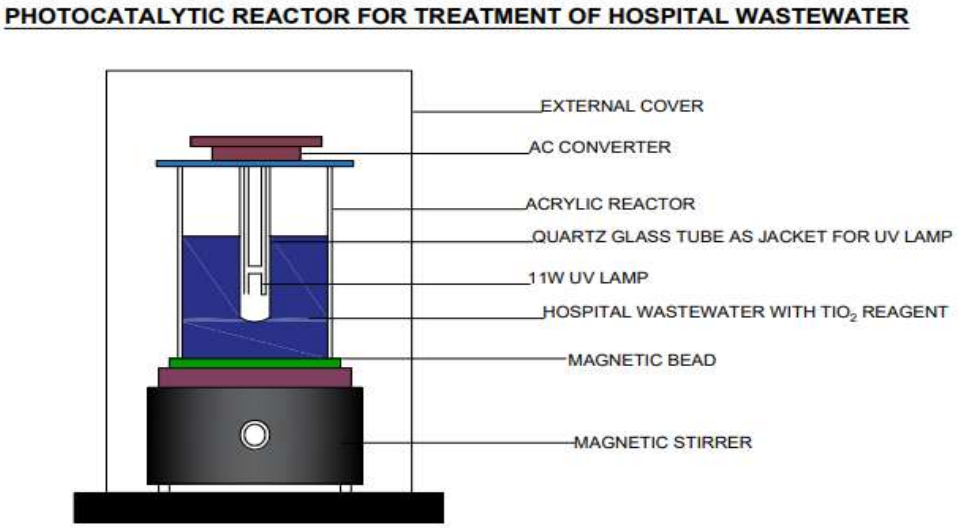
Nano adsorbent Treatment:

Hospital wastewater was treated with TiO_2 nanoparticles, which act as both adsorbents and photocatalysts. The mixture was agitated on an orbital shaker at 200 rpm for 1 hour to ensure uniform dispersion of TiO_2 and maximize pollutant adsorption. After agitation, the mixture was allowed to settle for 30 minutes, allowing TiO_2-laden pollutants to settle at the bottom. The clear supernatant was then decanted or filtered, leaving behind the treated water and pollutant-loaded TiO_2 particles.

Photocatalytic Treatment:

The photocatalytic performance of green-synthesized TiO_2 nanoparticles from Guava leaf extract was tested on hospital wastewater. sample was treated with TiO_2 for 30 minutes at ambient conditions without UV light, primarily relying on adsorption to reduce pollutant concentrations. The TiO_2 nanoparticles, with high surface area, adsorbed organic compounds and pharmaceutical residues. UV light was then applied

to activate the photocatalytic properties of TiO_2, breaking down pollutants into non-toxic byproducts. The process showed promise in reducing chemical contaminants, offering an energy-efficient and sustainable approach for hospital wastewater treatment.



Result and Conclusion:

The TiO2 nanoparticles synthesized from Guava leaf extract are expected to exhibit high photocatalytic activity under UV-light, effectively degrading pollutants in hospital wastewater. This method is environmentally friendly, as it avoids the use of harmful chemicals typically involved in traditional synthesis methods. Green synthesis is generally more cost-effective compared to conventional methods, as it uses freely available plant extracts. The use of plant extracts in the synthesis process reduces the overall toxicity of the nanoparticles, making them safer for potential biomedical applications. Overall, this project aims to provide a sustainable, efficient, and cost-effective solution for treating hospital wastewater, contributing to environmental protection and public health

Industry Relevance:

Healthcare Industry: Hospital Wastewater Treatment Plants (WWTPs) Hospitals discharge wastewater containing pharmaceuticals, disinfectants, and pathogens. This green photocatalytic treatment could be implemented directly at hospital WWTPs to degrade harmful organic compounds and reduce microbial contamination before the water is released or reused.

Pharmaceutical and Chemical Industries: Effluent Treatment Units (ETUs) These industries generate wastewater with high chemical oxygen demand (COD) and traces of APIs (active pharmaceutical ingredients). Green TiO_2 nanoparticles can enhance the breakdown of these complex molecules in an eco-friendly, cost-effective manner.

Environmental Engineering & Urban Wastewater Management: Decentralized Wastewater Treatment Systems (DEWATS) In urban or rural areas without central wastewater treatment, compact treatment modules using green-synthesized TiO_2 could be developed. These systems can be integrated into existing greywater or blackwater treatment schemes for community-level sanitation.

Future Scope:

The scope of this project focuses on the sustainable treatment of hospital wastewater using green-synthesized TiO_2 nanoparticles derived from Guava leaf extract. Hospital wastewater contains harmful pollutants like pharmaceutical residues, heavy metals, and pathogens, which are difficult to remove with traditional methods. This project explores the photocatalytic properties of TiO_2 nanoparticles to effectively degrade organic contaminants and adsorb pollutants. The green synthesis of TiO_2 nanoparticles ensures an eco-friendly approach, avoiding toxic chemicals and energy-intensive processes. By using TiO_2 nanoparticles in both adsorption (without UV light) and photocatalysis (with UV light), the project aims to evaluate and enhance wastewater treatment efficiency, focusing on the reduction of chemical oxygen demand (COD), pharmaceutical residues, and microbial contamination. The findings can contribute to the development of sustainable water treatment technologies, offering an energy-efficient and environmentally friendly solution for hospital wastewater and potentially other industrial applications.