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(57) Abstract :
The present invention discloses a sustainable photocatalytic system for the effective degradation of black dye in industrial wastewater using green synthesized spinel ferrite nanoparticles. The nanoparticles are produced through a plant-mediated synthesis method employing natural phytochemicals as reducing and stabilizing agents, thereby eliminating hazardous chemicals and supporting eco-friendly fabrication. The synthesized nanomaterials exhibit a spinel crystal structure, high surface area, visible light responsiveness, and magnetic properties that allow easy recovery after treatment. Under solar or visible light irradiation, the nanoparticles generate reactive oxygen species that oxidize and mineralize complex dye molecules into non-toxic products such as carbon dioxide and water. The system reduces color intensity and chemical oxygen demand while minimizing sludge generation. Magnetic recoverability ensures catalyst reusability and operational cost reduction. The invention provides an environmentally benign, energy-efficient, and scalable approach for advanced wastewater remediation and sustainable water management.

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