**Title:** Nanoparticles in Photocatalysis: Innovations driving Sustainable Dye degradation in Wastewater Treatment

**Abstract**

The rapid industrialization and growing reliance on synthetic dyes have caused a notable rise in water contamination, posing severe threats to aquatic habitats as well as human health. Photocatalysis, an advanced oxidation process, has emerged as a promising and eco-friendly strategy for the treatment of wastewater, particularly for degradation due to persistent dye pollutants. Recent advancements in nanotechnology have further enhanced the efficiency of photocatalytic processes, with nanoparticles playing a pivotal role because of their huge surface area, distinct physicochemical characteristics, and exceptional catalytic activity. This review comprehensively explores the innovations in photocatalysis driven by nanoparticles, with an emphasis on using nanoparticles that have been greenly produced. These nanoparticles, derived from plant extracts or other environmentally benign methods, offer a sustainable substitute for traditional synthesis methods by lowering the environmental effect and using less hazardous chemicals. The paper delves into the synthesis routes, characterization techniques, and mechanistic insights into dye degradation using green nanoparticles as photocatalysts. This review provides a useful tool for practitioners and scholars looking to develop innovative and eco-friendly strategies for dye degradation and water purification.

**Keywords**: Photocatalysis, Advanced Oxidation Processes, Green Synthesis, Nanoparticles, Biological Synthesis