

## **Eco-friendly photocatalyst derived from egg-shell waste for methylene blue dye degradation**

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The growing concern over environmental pollution (water) and the need for sustainable greener solutions has prompted extensive research into novel materials for pollutant remediation. The present study reports a novel approach to synthesize an eco-friendly photocatalyst by impregnating egg-shell waste with bentonite for the degradation of methylene blue dye, a common and persistent water pollutant. The synthesis of the catalyst was achieved by mixing the egg-shell waste powder with bentonite powder by optimizing the blending ratios (0:100; 20:80; 40:60; 50:50; 60:40; 70:30). Cylindrical-shaped calcined (at 900 °C) composite pellets of 2 mm in height were evaluated for their photocatalytic activity in the degradation of Methylene Blue dye ( $\lambda_{\text{max}} = 664 \text{ nm}$ ) under the sunlight. The effect of various studies like kinetic, adsorption and pH are systematically investigated to determine the dye degradation behaviour of the photocatalytic material using Tungsten filament bulb (100 W) as the light source. Comparisons are made with other conventional photocatalysts: bentonite only in sunlight, composite in the dark, and zero adsorbent conditions in sunlight, to highlight the efficiency and sustainability of the proposed composite material kept in sunlight. Catalyst material follows the first order kinetics ( $R^2 = 0.9709$ ) with the multilayer adsorption mechanism ( $R^2 = 0.9768$  for Freundlich isotherm) and confirms the highest efficiency at basic pH values (11.98). The findings of this study demonstrate the promising potential of the bentonite-impregnated egg-shell waste composite as an effective green photocatalyst for the degradation of methylene blue dye. This research bridges the gap between waste utilization and environmental remediation, paving the way for future advancement in the field of photocatalysis and green materials.

**Keywords:** photocatalyst, egg-shell, bentonite, methylene blue dye

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