

Experimental Investigation of Synthetic Food Dye Removal Using Sustainable Vegetable Waste Adsorbents

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Abstract: *The extensive use of synthetic food dyes in processed foods has become a major concern due to their potential health hazards and environmental impact. Wastewater generated during food processing and manufacturing often contains residual synthetic colorants that require effective treatment before disposal. This study presents an experimental investigation of the removal of synthetic food dyes using sustainable vegetable waste-derived adsorbents. Low-cost bioadsorbents were prepared from commonly available vegetable waste materials and evaluated for their adsorption performance under different operating conditions.*

The adsorption experiments were carried out by varying key process parameters, including solution pH, contact time, adsorbent dosage, initial dye concentration, and temperature, to determine the optimum conditions for dye removal. The prepared bioadsorbents were characterized using surface morphology and functional group analysis to understand the adsorption mechanism and identify the active sites responsible for dye uptake. The adsorption behavior was further examined using isotherm, kinetic, and thermodynamic models to evaluate the efficiency and feasibility of the process.

The experimental results demonstrated that chemically activated vegetable waste adsorbents achieved high removal efficiencies for synthetic food dyes. Maximum adsorption was observed under optimized operating conditions, with adsorption following the Langmuir isotherm model and pseudo-second-order kinetic model, indicating monolayer chemisorption as the dominant mechanism. Thermodynamic analysis confirmed that the adsorption process was spontaneous and favorable, while regeneration studies showed that the adsorbents retained significant adsorption capacity after repeated use.

The findings demonstrate that vegetable waste-derived bioadsorbents provide an efficient, economical, and environmentally sustainable solution for the removal of synthetic food dyes from contaminated water. In addition to reducing dye pollution, this approach promotes the beneficial utilization of vegetable waste, supporting circular economy principles and sustainable wastewater treatment technologies..

Keywords: Synthetic food dyes, Vegetable waste, Bioadsorbents, Adsorption, Sustainable wastewater treatment, Food colorants, Langmuir isotherm, Pseudo-second-order kinetics, Dye removal, Waste valorization, Circular economy, Environmental sustainability.