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Integrated Detection and Sustainable Removal of Synthetic Food Colorants Using Advanced Vegetable Waste-Based Bioadsorbent Materials

[1]Megha Chauhan and [2]Dr. Jayati Chatterjee Mitra
[1]Research Scholar and [2]Professor
Dr. C V Raman University, Kota, Bilaspur

Abstract: *The widespread use of synthetic food colorants in processed foods has raised increasing concerns regarding food safety, environmental pollution, and public health. Excessive consumption of these artificial dyes and their discharge into wastewater can pose significant risks due to their persistence and potential toxic effects. Therefore, there is a growing need for reliable detection techniques and sustainable treatment methods to monitor and remove these contaminants. This study proposes an integrated approach for the detection and removal of synthetic food colorants using advanced bioadsorbent materials developed from vegetable waste. The proposed framework combines analytical detection methods with eco-friendly adsorption technology to provide a comprehensive solution for food quality assessment and wastewater remediation.*

Vegetable waste materials are processed and modified to enhance their adsorption characteristics, including surface area, porosity, and functional groups responsible for dye binding. The developed bioadsorbents are evaluated for the removal of commonly used synthetic food colorants under different operating conditions, including variations in pH, contact time, adsorbent dosage, initial dye concentration, and temperature. Adsorption performance is analyzed using equilibrium, kinetic, and thermodynamic models to understand the adsorption mechanism and optimize the treatment process. The regeneration and reusability of the bioadsorbents are also investigated to assess their long-term practical applicability.

The experimental findings demonstrate that the modified vegetable waste-based bioadsorbents achieve high removal efficiencies for synthetic food dyes while maintaining low operational cost and minimal environmental impact. The integrated detection and adsorption strategy enables effective monitoring and purification of dye-contaminated samples, supporting both food safety and environmental sustainability. The study highlights the potential of converting agricultural and vegetable waste into value-added bioadsorbent materials for the development of affordable, efficient, and environmentally friendly technologies for synthetic food colorant management.

Keywords: Synthetic food colorants, Vegetable waste, Bioadsorbents, Adsorption, Food safety, Dye detection, Wastewater treatment, Sustainable remediation, Agricultural waste valorization, Environmental pollution, Adsorption kinetics, Isotherm modelling.

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