Abstract

Water pollution caused by synthetic dyes is a major environmental concern due to their toxicity, persistence, and non-biodegradable nature. The development of cost-effective and eco-friendly adsorbents is therefore of great importance for wastewater treatment. In the present study, mucilage extracted from *Plantago major* seeds was investigated as a natural adsorbent for the removal of methyl orange (MO) dye from aqueous solutions. The mucilage was prepared, characterized, and applied for batch adsorption experiments. Structural and morphological features were examined using Fourier Transform Infrared (FTIR) spectroscopy, X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), and Energy Dispersive X-ray (EDX) analysis. FTIR confirmed the presence of hydroxyl, carboxyl, and amine and carbonyl groups, which serve as active sites for dye binding. SEM images revealed a porous and irregular surface morphology, while EDX analysis indicated the presence of carbon, oxygen, nitrogen, and mineral elements, supporting the heterogeneous biogenic composition of the material. Adsorption studies were conducted by monitoring the decrease in dye absorbance at different time intervals using UV-Vis spectroscopy. Results showed rapid initial adsorption followed by equilibrium, suggesting the suitability of the mucilage as an efficient natural adsorbent. The findings highlight seed mucilage as a low-cost, sustainable, and environmentally benign material with promising potential in dye removal and water purification applications.