Abstract

The major environmental threat of today is heavy metal pollution, for which various conventional approaches are employed for effective removal, resulting in the generation of secondary pollution and somewhat costly methods. This research investigates quince seed mucilage (QSM), a glucuronoxylan-rich polysaccharide, as a natural bioadsorbent for nickel (Ni_{2+}) removal from wastewater. The QSM from quince seeds were extracted and tested under varying operational conditions, including initial metal concentration, contact time, mucilage dose, pH, and temperature. For the evaluation of reusability, adsorption-desorption experiments were conducted. Even characterization techniques such as FTIR, XRD, SEM, and EDX were used to elucidate the occurrence of adsorption on the mucilage. The results revealed that QSM exhibited strong metal uptake with increasing ion concentration, with adsorption efficiencies ranging from 64.3 to 86.7% (500 to 2500 ppm). Rapid biosorption occurred, reaching a maximum of 94% at 30 min, suggesting favorable kinetics. The optimal mucilage dose was 0.04-0.06 g, achieving ~85% efficiency, though excessive dosage reduced performance. pH optimization showed the highest removal (82.5%) at neutral pH 7, while acidic conditions suppressed adsorption due to protonation of binding sites. Temperature positively influenced uptake, peaking at 92.2% at 50 °C before slightly declining at higher levels. Sorption-desorption studies confirmed ~34% recovery, supporting partial reusability. Characterization confirmed that hydroxyl and carboxyl groups actively participated in Ni^{2+} binding. The characterization techniques, such as FTIR band shifts, XRD peak changes, SEM surface roughening (an average pore size of 61.1 ± 9.7 μm), and EDX elemental composition, collectively confirmed Ni^{2+} adsorption before and after treatment. Overall, in heavy metal removal, QSM is a low-cost, biodegradable, and efficient bioadsorbent along with promising scalability for wastewater treatment. Further research is recommended on regeneration techniques, multi-metal systems, and pilot-scale applications to validate the practical efficiency and sustainability of QSM in wastewater treatment.