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Adsorptive removal of chromium (VI) from aqueous solutions using activated carbon derived from Calabash (*Crescentia cujete*) fruit shell

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Heavy metal contamination, particularly from hexavalent chromium [Cr(VI)], poses a significant environmental and health hazard due to its toxicity and persistence in aquatic systems. Conventional Cr(VI) treatment methods are often costly, complex, and generate secondary pollutants, necessitating sustainable alternatives. This study investigates the potential of activated carbon derived from Calabash (*Crescentia cujete*) fruit shells as a low-cost, eco-friendly adsorbent for Cr(VI) removal from aqueous solutions. Activated carbon was prepared through controlled carbonization at 400 °C for 40 minutes using a muffle furnace**,** followed by chemical activation using H_3PO_4. The physicochemical properties of carbonized samples at various temperatures were analyzed to determine the optimum carbonization temperature. Batch adsorption experiments were conducted at room temperature (30 °C) and pH 2 to examine the effects of key operational parameters such as initial Cr(VI) concentration, adsorbent dosage, and contact time. The concentration of Cr(VI) in solutions was determined using a UV-Vis spectrophotometer at 542 nm with the 1,5-diphenylcarbazide method. Physicochemical characterization revealed that carbonization at 400 °C produced the optimal adsorbent, with the highest fixed carbon content (70.89%) and moderate ash content (3.29%). Optimization results indicate that activation significantly enhances adsorption, with activated carbon achieving 93.25 ± 0.42% removal at 1 ppm, compared to 76.73 ± 0.48% for non-activated carbon and 68.89 ± 0.46% for raw material of calabash fruit shell. Adsorption efficiency decreased at higher Cr(VI) concentrations. The optimal adsorbent dosage was 0.4 g, at which activated carbon, non-activated carbon, and raw material achieved higher removal efficiencies. Beyond this dosage, further increases yielded minimal additional removal. The optimal contact time was 60 minutes, where activated carbon, non-activated carbon, and raw material achieved removal efficiencies of 93.14 ± 0.50%, 76.76 ± 0.42%, and 68.64 ± 0.62%, respectively. By 60 minutes, removal efficiency had reached a near-optimal level, with only minor improvements thereafter. These findings suggest activated carbon from Calabash fruit shells is a promising, cost-effective, and sustainable alternative for Cr(VI) removal in wastewater treatment, contributing to environmental protection and resource recovery.

Keywords:
Hexavalent Chromium, Adsorption, Activated Carbon, UV-Vis Spectrophotometry, Wastewater treatment.