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Highly Effective Removal of Toxic Cr(VI) from Wastewater Using Sulfuric Acid-Modified Avocado Seed

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Abstract

Sulfuric acid modified avocado seed (ASSA), as a low-cost carbonized adsorbent, was investigated for the removal of toxic Cr(VI) from water/wastewater in batch experiments. A low temperature (100 °C) chemical carbonization treatment was employed for the production of the adsorbent. FE-SEM and HR-TEM images revealed the formation of agglomerated and rodlike structured particles after carbonization of avocado seed. BET and TGA analyses of ASSA demonstrated its mesoporous structure and thermal stability up to 200 °C. The presence of oxo-functional groups on the ASSA surface was confirmed by ATR-FTIR and XPS studies. Adsorption of Cr(VI) onto ASSA was highly pH dependent and found to be an optimum at pH 2.0. Adsorption isotherm results suggested that the capacity increases with an increase in temperature. Nonlinear regression analysis revealed that the Freundlich isotherm model provides a better correlation than the Langmuir isotherm model for Cr(VI) adsorption onto ASSA. The maximum Cr(VI) adsorption capacity of 333.33 mg/g was obtained at 25 °C, which is higher than most of the previously reported carbonized adsorbents used for Cr(VI) removal. Adsorption kinetics was best described by the pseudo-second-order model. The presence of coexisting ions slightly affected the Cr(VI) removal efficiency of ASSA. Experiment with real wastewater sample containing 47.34 mg/L of Cr(VI) demonstrated that by the use of only 0.03 g/25 mL of ASSA, almost 100% removal was achieved at pH 2.0, which suggests its potential application in wastewater treatment plants. The ASSA retained its original Cr(VI) sorption capacity up to three consecutive adsorption–desorption cycles. Finally, from XPS analysis, electrostatic attraction of Cr(VI) species to the adsorbent and its subsequent reduction to Cr(III) were identified as the leading removal mechanisms.