



RESEARCH

Two - Stage Catalytic Activation of Coconut Shell Biochar for Effective Malachite Green Removal from Water

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ABSTRACT

This study investigates scientific insights into the adsorption mechanism of novel engineered biochar derived from coconut shells via catalytic conversion with FeCl_3 for Malachite Green removal. This is a unique research report describing the use of novel engineered biochar derived from waste coconut shells for the removal of the cationic dye "Malachite Green" by understanding the insights into the adsorptive removal mechanism. The engineered biochar was prepared with different concentrations (5 %, 7 %, and 9 %) of iron catalyst (FeCl_3) and at different pyrolysis temperatures: 200 °C, 300 °C, and 400 °C with residence time of 4 hours. An adsorption analysis was planned under the set of experimental conditions: dosage 1g/L; pH 6; rpm 150; holding time 72 hours to identify the best-engineered biochar. The adsorptive performance was checked with artificially polluted water. The engineered biochar with the high q_e value (amount of adsorbate removed by unit weight of engineered biochar) was selected. Detailed isotherm analysis, Kinetics study, thermodynamics analysis, and rate-limiting factor analysis were carried out for engineered biochar with higher adsorptive capacity. The biochar treated with 9% FeCl_3 and pyrolysed at 400 °C showed the highest adsorption capacity of 50.20 mg/g for Malachite Green due to increased mineral components and a denser carbon network. Isotherm analysis revealed that the Freundlich model fits well, and the adsorption nature of Malachite Green by 9% CSBC 400 is a multilayer. The results of the adsorption kinetic study revealed that the pseudo-second order model fits well, indicating that the chemisorption process plays a significant role in the removal of Malachite Green by 9% CSBC 400. The adsorption process is spontaneous and endothermic. Therefore, the engineered biochar produced by the iron catalyst is a novel adsorbent for Malachite Green removal. This innovative finding of the use of engineered biochar produced from coconut shells for the removal of malachite green opens the door to the development of novel strategies for the effective removal of dye at the commercial level.