Jujube stones based highly efficient activated carbon for methylene blue adsorption: Kinetics and isotherms modeling, thermodynamics and mechanism study, optimization via response surface methodology and machine learning approaches

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Abstract

Water contaminated by methylene blue (MB) dye was treated with activated carbon based on locally collected jujube stones. This activated carbon was characterized by physico-chemical methods after preparation and chemical activation. Response surface methodology (RSM) was used to maximize the MB uptake a dependent variable in Box-Behnken Design (BBD) with the initial concentration of methylene blue (400–700 mg/L), adsorbent dosage (0.6–1.6 g/L), contact time (30–540 min), pH (7–11) and temperature (20–50 °C) as independent variables. Then, the database created by BBD was further modeled using Gaussian Process Regression coupled with Bagging (Bootstrap Aggregation_Bag) and Dragonfly optimization algorithm (GPR_DA_Bootstrap). The results of the optimization analysis using the GPR_DA_Bootstrap model are shown to be superior to those of the BBD model. The experimental validation of the optimal conditions of the GPR_DA_Bootstrap model (X_1 = 700 mg/L, X_2 = 0.6 g/L, X_3 = 540 min, X_4 = 11, and X_5 =50 °C) led to an MB uptake (501.01 mg/g) significantly higher than that of BBD (456.00 g/g). In addition, the very low error between the experimental and the predicted values given by the GPR_DA_Bootstrap model (8.64 mg/g) compared to that of the BBD model (22.19 mg/g), should be highlighted. This clearly shows the efficiency and the performance of the GPR_DA_Bootstrap model on the one hand; as well as the effectiveness of activated carbon prepared from jujube stones (*PJAC)* as a low-cost adsorbent on the other hand.