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Engineered Bio-Coal from Pressed Seed Cake for Removal of 2, 4, 6-Trichlorophenol with Parametric Optimization Using Box–Behnken Method

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Abstract : In the present study, engineered bio-coal was produced from pressed seed cake, which otherwise is non-edible in origin. The production process involves a slow pyrolysis wherein, based on the optimization of process parameters; a substantial reduction in H/C and O/C of 77% was achieved with respect to the original ratio of 1.67 and 0.8, respectively. The bio-coal, so the product was found to have a higher heating value of 29899 kJ/kg with surface area 17 m^2/g and pore volume of 0.002 cc/g. The functional characterization of bio-coal and its subsequent modification was carried out to enhance its active sites, which were further used as an adsorbent material for removal of 2,4,6-Trichlorophenol (2,4,6-TCP) herbicide from the aqueous stream. The point of zero charge for the bio-coal was found to be pH < 3 where its surface is positively charged and attracts anions resulting in the maximum 2, 4, 6-TCP adsorption at pH 2.0. The parametric optimization of the adsorption process was studied based on the Box-Behken design with the desirability approach. The results showed optimum values of adsorption efficiency of 74.04% and uptake capacity of 118.336 mg/g for an initial metal concentration of 250 mg/l and particle size of 0.12 mm at pH 2.0 and 1 g/L of bio-coal loading. Negative Gibbs free energy change values indicated the feasibility of 2,4,6-TCP adsorption on biochar. Decreasing the ΔG values with the rise in temperature indicated high favourability at low temperatures. The equilibrium modeling results showed that both isotherms (Langmuir and Freundlich) accurately predicted the equilibrium data, which may be attributed to the different affinity of the functional groups of bio-coal for 2,4,6-TCP removal. The possible mechanism for 2,4,6-TCP adsorption is found to be physisorption (pore diffusion, p*_p electron donor-acceptor interaction, H-bonding, and van der Waals dispersion forces) and chemisorption (phenolic and amine groups chemical bonding) based on the kinetics data modeling.

Keywords : engineered biocoal, 2, 4, 6-trichlorophenol, box behnken design, biosorption
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