Fixed-bed dynamic column adsorption study of methylene blue (MB) onto pine cone

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ABSTRACT

The effectiveness of pine cone biomass in the removal of methylene blue (MB) dye from its aqueous solution was tested here by a fixed-bed column adsorption study. The adsorption column breakthrough curves (BTCs) indicated the favourable column dynamics and its dye adsorptive behaviour depends on feed flow rate, initial MB dye concentration and column bed height. The results showed that the amount of total sorbed dye, equilibrium dye uptake, mass transfer zone and total percentage of dye removal increased with increase in MB dye concentration and the height of the bed, but decreased with increase in initial flow rate. To determine the fixed-bed column adsorption kinetic parameters, Thomas, Yoon–Nelson and Bed Depth Service Time (BDST) models fitted the experimental BTC obtained from dynamic studies. All these parameters are required for the design of adsorption column and it was found that all three kinetic models were applicable. Thomas model showed that the value of maximum solid-phase concentration ($q_0$) decreased when the flow rate and the height of the bed increased but increased with increasing initial MB dye concentration. The value of Thomas kinetic rate constant ($K_{Th}$) increased with higher flow rate but decreased with increasing initial MB dye concentration and the height of the bed. Yoon–Nelson model showed that the time required to achieve 50% adsorbate breakthrough ($\tau$) fitted well with the experimental data ($\tau_{50\%\ exp.}$) in the entire column adsorption system. The rate constant $K_{YN}$ increased with both increasing flow rate and initial MB dye concentration but decreased with increasing bed height. The BDST model showed that the rate constant ($K_0$) decreased when both the bed heights and the initial MB dye concentration increased, but increased with the increase in flow rate. The value of the volumetric sorption capacity of the bed ($N_0$) increased with increasing flow rate, initial MB dye concentration and bed height. Overall, all the three models were fitted well with the experimental data.

Keywords: MB adsorption; Fixed-bed column; BTC, Thomas model; Yoon–Nelson model

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