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Comparative analysis of fixed-bed sorption models using phosphate breakthrough curves in slag filter media

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ABSTRACT

Fixed-bed kinetic sorption (Bohart–Adams, Thomas, Yoon–Nelson, Clark, Wolborska, and modified dose-response) models are commonly used to simulate breakthrough curves (BTCs) from fixed-bed systems. However, more caution should be taken in using these models. Some researchers misused the equation, which is a totally different type from the original model, as a simplified model. Others used the same equation expressed in different forms as an independent model. The aim of this study was to clarify the fixed-bed sorption models via comparative analysis using the phosphate BTCs in slag filter media. For the analysis, the breakthrough data for phosphate (initial phosphate concentration = 1.0 and 2.0 mg/L) sorption in fixed-bed columns (inner diameter = 2.5 cm and column length = 10, 20, and 30 cm) were obtained from the experiments. The original Bohart–Adams model was simplified in the literature to the convergent- and divergent-type models in order to be used for the BTC analysis. However, the divergent-type model, which is equivalent to the Wolborska model, should not be the type of Bohart–Adams model used, because it behaves totally different from the original model. Also, the Thomas and Yoon–Nelson models should not be used simultaneously with the Bohart–Adams model, because they are equivalent to the simplified convergent-type Bohart–Adams model, and the parameters of both of the models (k_T, q_0, k_{YN}, and τ) can easily be calculated from the Bohart–Adams model parameters (k_{BA} and N_0). The Bohart–Adams, Clark, and modified dose-response models could describe the BTCs relatively well with a high determination coefficient and a low chi-square coefficient. From this study, the Bohart–Adams, Clark, and modified dose-response models are recommended for the BTC analysis, because these models can provide useful design parameters (k_{BA}, N_0, Z_0, t_b, and q_0) for the fixed-bed systems.

Keywords: Breakthrough curves; Fixed-bed kinetic sorption models; Bohart–Adams model; Clark model; Modified dose-response model; Slag filter media

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