Application of Taguchi experimental design methodology in optimization for adsorption of phosphorus onto Al/Ca-impregnated granular clay material

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ABSTRACT

The adsorption of phosphorus in a fixed bed was investigated using the Taguchi experimental design. The abilities of two types of granular adsorbents, Al- and Ca-impregnated granular clay materials (Al-GCM and Ca-GCM), to adsorb phosphorus from an aqueous solution were evaluated, then controllable factors (the adsorbent material, initial phosphorus concentration, and flow rate) were optimized. An $L_9$ orthogonal array was used for the experimental design, and the conditions were optimized to achieve the best signal-to-noise ratio. The optimal conditions were using Ca-GCM as the material, an initial phosphorus concentration of 20 mg/L, and a flow rate of 600 $\mu$L/min. Under these conditions, the number of bed volumes at the breakthrough point was 354 and the Ca-GCM adsorption capacity for phosphorus was 9.12 mg/g. The relative importance of each controllable factor was determined using the analysis of variance method, which revealed that the type of adsorbent was the most influential factor, accounting for 55.5% of the phosphorus removal capacity. The initial phosphorus concentration was the next most influential factor, contributing 35.7% of the phosphorus removal capacity. The flow rate contributed only 8.8% of the phosphorus removal capacity. The main component of the product of the adsorption process was hydroxylapatite, which could be used in many industrial and agricultural processes. The treatment process was found to be relatively environmentally benign, and would be a way of regenerating phosphorus without causing secondary pollution.

Keywords: Taguchi design; Al- and Ca-impregnated clay material; Phosphorus adsorption; Recycling