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Factorial experimental design as a tool for screening the factors affecting Pb^{2+} and Ni^{2+} adsorption

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Abstract

Metal adsorption efficiency may be influenced by many operating conditions. It would be useful for the understanding of the complexity of adsorption systems to know the interactive effects of the factors involved. In this study 2^4 full factorial design experiments were used to screen the factors affecting the Pb^{2+} and Ni^{2+} removal efficiency using modified walnut shell. In factorial design experiments, four factors pH, adsorbent dose, initial concentration of metal ions and temperature were varied at two levels. Using the experimental results, a linear mathematical model was obtained. The adsorbent dosage was found to have the most significant influence on the Pb^{2+} removal efficiency. However for Ni^{2+} uptake, solution pH was the most important parameter.

Keywords: Adsorption, Factorial design, Modified walnut shell, Pb^{2+}, Ni^{2+}.

1. INTRODUCTION

Industrial activity generates large volumes of aqueous effluents containing high levels of hazardous species. There is an urgent need to treat these harmful effluents before being delivered into the environment. The species with the most toxicological relevance in the industrial effluents are the heavy metals, which are not biodegraded over time, being accumulated in human body [1]. One of the promising techniques for the removal of heavy metals from aqueous solutions is the use of waste materials as adsorbents. A wide range of low-cost porous solids, such as fly ash, saw dust, peat and nut shells have been used for this purpose.

Metal adsorption efficiency may be influenced by many operating conditions. The effects of various individual factors on the adsorption process have been studied extensively by one-variable-at-a-time experiments; however, it would be useful for the understanding of the complexity of systems to know the interactive effects of the factors [2]. The factorial experimental design involves altering all factors from one test to the next. The design determines which variable have significant effects on the response as well as how the effect of one variable varies with the level of the other variables [1].

In this study walnut shell was selected to investigate its adsorption efficiency for $Pb^{2+}$and Ni^{2+} removal. Walnut shell as an agricultural by-product is available in large amounts in Iran. Walnut shell in its natural form has been applied for removal of heavy metals in previous works [3-5]. The use of untreated agricultural wastes as adsorbents can bring some problems due to the release of soluble organic compounds contained in their materials [6]. As a result, in this study pretreated walnut shell was used as adsorbent to conduct a full factorial design analysis to screen the significant factors affecting of Pb^{2+} and Ni^{2+} adsorption process.

2. MATERIALS AND METHODS

2.1. Preparation of adsorbent

Walnut shell was first grounded and sieved to get a fraction with uniform particle size of 0.6-2.0 mm. Then; the grounded walnut shell was washed with distilled water to remove the fine impurities. It was subsequently soaked in 1.0 mol/L NaOH for 24 hours and then washed with distilled water till the supernatant solution reached normal pH. Finally this modified walnut shell was air dried and stored in a container for further use.

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