Sorption dynamics of some selected metals ions from aqueous solution using chitosan magnetized by fe2o3 nanoparticles

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KEYWORDS

Chitosan/iron magnetic nanocomposite; heavy metals; support materials; breakthrough; column models; fixed bed sorption system

SHORT SUMMARY

In this study, Chitosan/iron magnetic nanocomposite (C-Fe_2O_3) was synthesized and used to remove heavy metals from aqueous solutions. The synthesized nanocomposite was first characterized through scanning electron microscopy (SEM), X-ray Fluorescence (XRF), and Fourier transform infrared (FT-IR). Batch isotherm experiments were carried out to evaluate the removal of (Cu(II), Cr(II), Pb(II), Se(II), and Zn(II)) from aqueous solutions, parameters such as contact time, adsorbent dose, and initial metal concentration were studied to optimize the conditions to be utilized for the decontamination of effluents using a batch adsorption technique. Under optimum conditions the Cu(II), Cr(II), Pb(II), Se(II), and Zn(II) removal efficiency achieved was 99%, 93.8%, 97.8%, 99.2%, and 98.8%, respectively. Adsorption parameters were determined using Langmuir and Freundlich isotherms, the experimental data were fitted to the Langmuir and Freundlich models. The results obtained from batch experiments adsorption were used to remove metal ions by column to be utilized commercially. Break-through curves were obtained to investigate the influence of flow rate, and the bed height of the (C-Fe_2O_3) on the removal of heavy metal ions. The regeneration study confirmed the excellent shelf life of C-Fe_2O_3 with only a slight loss in the removal efficiency (< 4.2%).

EXTENDED ABSTRACT

The number of toxic pollutants increased as a result of industrialization as well as the increase in human activities [1]. Removal of heavy metals from wastewater is most importance. Heavy metals have long-term masking potential, highly toxic to man through the food chain. Consequently, the removal of heavy metals from wastewater is essential [2]. There are several ways to remove heavy metals from water such as ion exchange [3], a reverse osmosis method [4], membrane filtration, chemical coagulation [5], electrochemical techniques [6][7][8], constructed wetlands [9], and the application of nano-materials for the adsorption of heavy metals has arisen as an interesting area of research due to their higher surface area and greater active sites for interaction with pollutants [10]. To increase the adsorption efficiency of the used adsorbents, the magnetization of used adsorbents is a promising method. The coating used adsorbents with magnetic nanoparticles, and Fe_2O_3 nanoparticles have been widely used. When these particles are combined with other materials, such as chitosan, the agglomeration mechanism is hampered [11]. Chitosan is a natural hydrophilic and cationic biopolymer obtained by the removal of acetyl-chitin groups in an alkaline environment and has been extensively studied as an adsorbent to remove a variety of contaminants, chitosan magnetized by Fe_2O_3 nanoparticles has also been employed for eradicating heavy metals from solutions [12]. It was found that the performance of iron magnetic nanoparticles (C-Fe_2O_3) was suitable for the removal of heavy metals from aqueous solutions. In addition, studies on the removal of heavy metals by the C-Fe_2O_3-based adsorption process have not yet been reported. Therefore, the present study offers a comprehensive account of the application of C-Fe_2O_3 as an efficient and recyclable adsorbent for the removal of heavy metals from aqueous solutions. the surface and structural characterizations of used C-Fe_2O_3 are obtained by advanced characterization analyses. The adsorption process of the heavy metals and C-Fe_2O_3 couple is reported with different environmental parameters. Isotherm, kinetics studies, as well as fixed bed sorption system.

Column dynamics have been investigated by using Tomas models and are conducted using linear and nonlinear kinetic models.

2. Experimental

2.1. Synthesis of iron magnetic nanoparticles aided with chitosan (C-Fe_2O_3)

Initially, 2 g of chitosan was dissolved in (100 mL) 2% acetic acid and stirred at 120 rpm for 1 h. A mixture of $FeCl_3$ $6H_2O$ (6.1 g) with $FeCl_2.4H_2O$ (4.2 g) was mixed with the chitosan solution with the simultaneous dropwise addition of NaOH solution at pH > 12.0 [12].

2.2. Characterization Analyses

The characterizations of the C-Fe_2O_3 sample were performed using XRF, SEM, and FT-IR spectroscopy. The magnetization nanoparticles of C-Fe_2O_3 were measured before and after the removal of heavy metals.

2.3. Adsorption study, and Break-through curve experiments

The breakthrough curve for the column was determined by plotting the ratio of the C_t/C_0 (C_t and C_0 are the heavy metals concentration of effluent and influent, respectively) against the time. Experimental parameters such as the effect of initial metal ions concentration, contact time, and thickness of C-Fe_2O_3. The batch experiment was carried out by adding adsorbents material in column bed depth (1.5, 5.0, 10) cm. Addition of different concentration from metals ions (0.50 mg/L, 1.0 mg/L, 2.0 mg/L, and 3.0 mg/L), Sampling intervals were 15. 30. 60. 90 and. 120 min, feed flow rate (2.0 to 20 mL/min), the remaining concentration of the ions was analyzed after passing through column bed.

Results

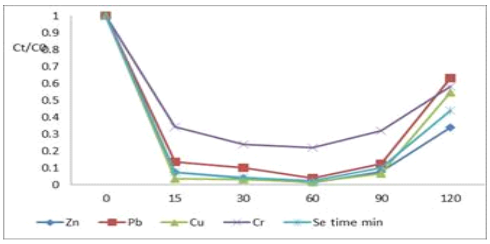

Figure 1: effect of contact time

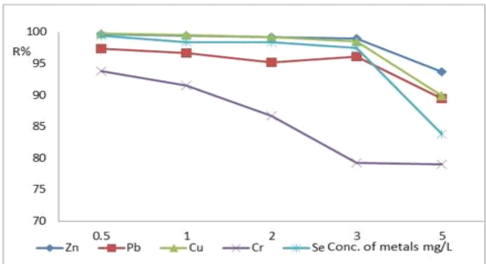

Figure 2: effect of initial concentration

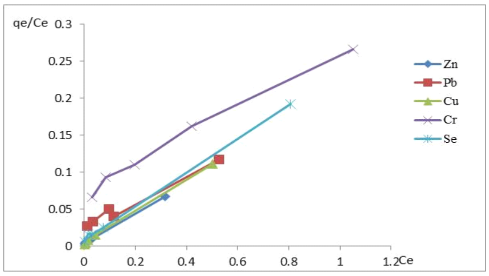

Figure 3: Langmuir isotherm models

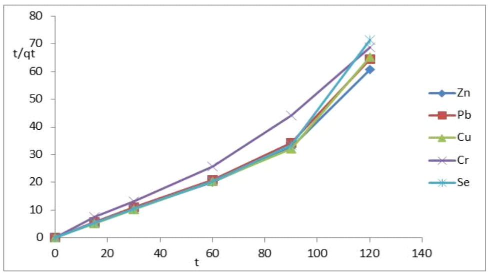

Figure 4: Second order model

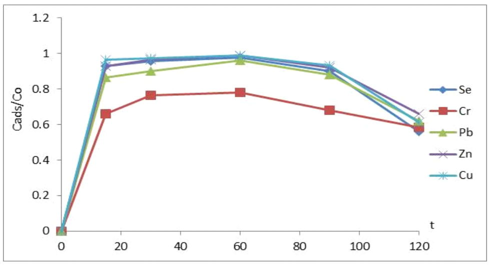

Figure 5: Break-through curve

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