Removal of lead, cadmium, and mercury ions using biosorption

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ABSTRACT

The biosorption of Pb (II), Cd (II), and Hg (II) from simulated aqueous solutions using baker’s yeast biomass was investigated. Batch type experiments were carried out to find the equilibrium isotherm data for each component (single, binary, and ternary), and the adsorption rate constants. Kinetics pseudo-first and second-order rate models applied to the adsorption data to estimate the rate constant for each solute, the results showed that the Cd (II), Pb (II), and Hg (II) uptake process followed the pseudo-second-order rate model with ($R^2$) 0.963, 0.979, and 0.960, respectively. The equilibrium isotherm data were fitted with five theoretical models. Langmuir model provides the best fitting for the experimental results with ($R^2$) 0.992, 0.9987, and 0.9995 for Cd (II), Pb (II), and Hg (II), respectively. The effect of various influent adsorbates concentration, and flow rate on the performance of fixed bed adsorber was found for the three heavy metals. A mathematical model was formulated to describe the breakthrough curves in the fixed bed adsorber for each component. The results show that the mathematical model provides a good description of the adsorption process for Cd (II), Pb (II), and Hg (II) onto fixed bed of baker’s yeast biomass.

Keywords: Biosorption; Yeast; Cd (II); Pb (II); Hg (II); Fixed bed; Mathematical model; Mass transfer coefficient

1. Introduction

The intensification of industrial activity during recent years is greatly contributing to the increase of heavy metals in the environment, mainly in the aquatic systems [1]. Wastewater contained with heavy metals is a serious environmental problem because they do not undergo biodegradation and are accumulated into the organism entering into the food chains [2]. Metals can be toxic to microbial population at sufficiently high concentrations. However, some metals are markedly more toxic even at very low levels. Among the toxic heavy metals, mercury, lead, and cadmium, “called the big three” are in the limelight due to their major impact on the environment; Lead and cadmium are potent neurotoxic metals [3].

The sources of human exposure to Cd (II) include atmospheric, terrestrial, and aquatic routes [4]. The most severe form of Cd (II) toxicity in humans is “itai-itai”, a disease characterized by excruciating pain in the bone [5]. Other health implications of Cd(II) in humans include kidney dysfunction, hepatic damage, and hypertension [6]. However, it has been suggested that overall nutritional status (rather than more Cd (II) content of food) is a more critical factor in determining Cd (II) exposure [7].

Lead (II) is heavy metal poison which forms complexes with oxo-groups in enzymes to affect virtually all steps in the process of hemoglobin synthesis and prophyrin metabolism. Toxic levels of Pb (II) in man...