Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2017.20565

74 (2017) 197–206
May

Cadmium removal from simulated chloride wastewater using a novel flow-by fixed bed electrochemical reactor: Taguchi approach

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Received 29 August 2016; Accepted 1 February 2017

ABSTRACT

Taguchi parameter design approach was used for optimization of process parameters for cadmium removal from chloride simulated wastewater using a flow-by fixed bed electrochemical reactor composed of a vertical stack of stainless steel screens. The studied process parameters were metal ion concentration, current, flow rate, and mesh number of screen. Removal and current efficiencies combined with energy consumption were considered as responses for optimizing of metal removal. An orthogonal array L_9, the signal-to-noise ratio and the analysis of variance (ANOVA) were used to analyze the effect of the selected parameters and their levels. ANOVA results indicate that only the current has the major effect on the removal efficiency (RE) while concentration has the major effect on both current efficiency (CE) and energy consumption (EC) followed by current. Flow rate and screen mesh number have a lower contribution on the performance of cadmium removal. The optimum values of the control factors were: [Cd] = 200 ppm, 1.72 A, 5 L/min, and 30 in^{-1} in which a higher RE of 99.0% was obtained at CE of 28%, EC of 9.0 kWh/kg, and electrolysis time of 50 min. The new electrochemical reactor was found to be more efficient in the removal of cadmium when compared with the traditional fixed bed electrochemical reactors because of the high rate of mass transfer that was observed.

Keywords: Heavy metals; Electrochemical reactor; Cadmium; Flow-by electrode; Taguchi method

1. Introduction

Heavy metals released into the environment have been increasing continuously as a result of industrial activities such as electroplating, photographic development, printed circuit board production, and battery technology [1]. The release of large quantities of these metals into the natural environment such as irrigation of agricultural fields by using sewages has resulted in a number of environmental problems due to their non-biodegradability and persistence [2]. Therefore, they can accumulate in the environment elements such as in food chain, and thus may pose a significant danger to human health [3]. Cadmium is one of the most important toxic metals which should be removed before discharging to environment. Cadmium has been classified by U.S. Environmental Protection Agency as a probable human carcinogen. Chronic exposure of cadmium results in kidney dysfunction and high levels of exposure will result in death [4].

A number of techniques have been used to remove heavy metals from wastewater effluents; including chemical precipitation [5], electrodialysis [6], ion-exchange process [7,8], adsorption onto activated carbon [9,10], low cost adsorbents such as kaolin, bentonite, blast furnace slag, and fly ash [11],

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