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Adsorption of cadmium from aqueous solution using Rooibos shoots as adsorbent

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The use of Rooibos shoots, a natural adsorbent, for cadmium removal from wastewater is proposed. The effects of initial pH, adsorbent dosage, contact time, and initial concentration were investigated in the batch adsorption mode. The optimum pH was found to be 5.5. Isotherm and kinetic data were modeled; the data fitted best to the Freundlich model, and, kinetically, the adsorption was of pseudo-second order as shown by the high R^2 value of 0.9928 along with close agreement between the experimental q_e (13.9 mg g^{-1}) and calculated q_e (14.24 mg g^{-1}) values. The studied biomass material was found to be effectively used for removal of cadmium from contaminated mine wastewater.

Keywords: Rooibos shoots; adsorption; cadmium; isotherm; kinetics

1. Introduction

Cadmium is one of the most hazardous trace metals due to its carcinogenicity and toxicity at low dose, together with good solubility and mobility in aqueous solutions (Waisberg et al. 2003). Cadmium may enter environmental waters through wastewater effluents from smelting, metal plating, and cadmium–nickel battery-producing industries. As it accumulates along the food chain, cadmium can cause human health hazards, leading to long-term effects such as renal dysfunction, hypertension, hepatic injury, and lung damage, and being teratogenic (Kazi et al. 2008). Toxicological studies have shown that short-term effects include nausea, vomiting, diarrhoea, and cramps (Kalkan et al. 2013). The maximum recommended concentration for drinking water established by the US Environmental Protection Agency is 0.01 mg L^{-1} (Volesky 1990). Methods for removal of the metal ions from industrial wastewaters are therefore welcome, to avoid contamination of ground water utilized as a source of drinking water.

For removal of trace metals from aqueous solutions, approaches such as chemical precipitation, reverse osmosis, solvent extraction, electrodialysis, and membrane separation have been suggested (Al-Masri et al. 2010; Kumar et al. 2011; Guyo, Mhonyera, and Moyo 2014; Moyo et al. 2014). These methods have been proven effective, but they are time-consuming and usually produce large amounts of sludge that can add other environmental problems (Saleh and Gupta 2012; Daraei et al. 2013; Daraei et al. 2014). Therefore, adsorption technique using waste materials is gaining popularity due to its merits of low cost, simplicity, effectiveness, fast operation, and of being environmentally friendly (Ali and Gupta 2007; Gupta et al. 2009; Daraei et al. 2015; Heidari et al. 2013; Mittal,

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