Chemical Papers 67 (5) 497–508 (2013)
DOI: 10.2478/s11696-012-0303-7

ORIGINAL PAPER

Removal of heavy metal ions from aqueous solutions using low-cost sorbents obtained from ash

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Received 12 August 2012; Revised 18 October 2012; Accepted 20 October 2012

This study's main objective was the development of effective low-cost sorbents for the removal of heavy metal ions from aqueous solutions. The influence of different factors on the sorption capacity of ash and modified ash as low-cost sorbents obtained by different methods was investigated. The synthesis of new ash-based materials was carried out at ambient temperature (20 °C), 70 °C, and 90 °C, respectively, in an alkaline medium with NaOH concentrations of 2 M and 5 M, respectively, corresponding to a mixture with solid/liquid ratios of 1 : 3 and 1 : 5, respectively. The prepared materials (sorbents) were characterised by scanning electron microscopy (SEM), energy dispersive X-ray analysis (EDAX), X-ray diffraction, and BET surface measurement. Adsorption isotherms were determined using the batch equilibrium method. The results showed that these types of new materials displayed a good capacity to remove copper, nickel, and lead ions (29.97 mg of Cu^{2+} per g of sorbent, 303 mg of Ni^{2+} per g of sorbent, and 1111 mg of Pb^{2+} per g of sorbent) from aqueous solutions. The modified materials were prepared using an alkaline attack (a recognised method used in previous studies), but Romanian ash from a thermal power plant was studied for the above purpose for the first time. Hence, the factors which affect the sorption capacity of the prepared low-cost sorbents were determined and their behaviour was explained, taking into account the composition and structure of the new materials.

Keywords: ash, characterisation, heavy metal, low-cost sorbent, sorbent synthesis

Introduction

Heavy metal ions can contaminate water resources in different ways: via industrial processes, paints, fertilisers, pesticides, animal manures, sewage sludge, wastewater irrigation, coal combustion residues, atmospheric deposition, etc. (Ciobanu et al., 2009; Wuana & Okieimen, 2011). The heavy metals most commonly found in contaminated waters are Pb^{2+}, Cr^{3+}, As^{3+}, Zn^{2+}, Cd^{2+}, Cu^{2+}, and Hg^{2+} (Zhang et al., 2010). Knowledge of the environmental chemistry and associated health effects of heavy metals is needed to understand their speciation, bioavailability, and removal options (Wuana & Okieimen, 2011).

Because heavy metal species cause serious problems in the environment, there has been a great motivation for the growing number of research devoted to effluent treatment processes (Derco et al., 2011; Harja et al., 2011a, 2012c; Um et al., 2009).

Some current methods for the removal of heavy metals involve their chemical precipitation from solutions. Other methods include coagulation–flocculation, electro-coagulation, cementation, membrane separation/filtration, solvent extraction, ion-exchange, adsorption, and biosorption (Xu et al., 2008; Harja et al., 2012a, 2012b; Piuleac et al., 2010; Rosales et al., 2012). The adsorption processes are based on the adsorptive properties of materials that can successfully immobilise heavy metals (Um et al., 2009).

A variety of sorbents can be used for adsorption,

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