Adsorption of Boron by Metallurgical Slag and Iron Nanoparticles

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ABSTRACT: Boron is a problematic pollutant because of the difficulty involved in removing it from water with an acceptable cost-to-benefit ratio, especially at extremely high concentrations (600 mg B/l). It is also necessary to remove the pollutant to comply with the quality criteria for drinking water (1 mg B/l) and even for agricultural irrigation purposes (0.5–15 mg B/l depending on crop tolerance). Although some newly proposed water-treatment technologies use economical adsorbents, they are unable to achieve the residual concentrations. The aim of this work is to show that adsorption using metallurgical slags (SL) can be used either as a pre-treatment of the zero-valent iron nanoparticles (nano-Fe^0) or as a final treatment itself for removing boron at high concentrations to obtain effluents complying with the standards established for drinking water and wastewater reuse. Adsorption tests (kinetics and isotherms) were carried out for both adsorbents. The slags showed good results as an adsorbent for boron removal in the pre-treatment and final treatment stages, with a very low cost compared with nano-Fe^0. The use of slags instead of expensive commercial adsorbents makes adsorption of water with high boron concentrations feasible, and allows obtaining treated wastewater for agricultural irrigation of very tolerant crops.

1. INTRODUCTION

Boron (B) is a semimetal found in water as boric acid (H_3BO_3) and tetraborate $[B(OH)_4]^-$ (Kabay *et al*. 2007). This metalloid causes teratogenic damage in different types of living beings (Moss and Nagpal 2003), but none of the identified research in this field concludes that this pollutant actually produces this effect in humans (Robbins *et al*. 2010). However, the guidelines recommended by the World Health Organization for drinking water establish a maximum permissible concentration of 1 mg B/l (USEPA 1994), and international standards for the concentration limit of boron in treated wastewater for irrigation recommend a range from 0.5 to 15 mg/l. These values were established based on the tolerance of various crops (Moss and Nagpal 2003; Table 1).

Several water-treatment technologies are reported for the removal of boron, including membrane processes (Hilal *et al*. 2011), electrocoagulation (Sayiner *et al*. 2008), coagulation–flocculation (Yilmaz *et al*. 2007), ion exchange (Li *et al*. 2011) and adsorption using commercial materials such as hydrotalcite (Yoshioka *et al*. 2007), amberlite IRA 743 (Boncukcuoglu *et al*. 2004) and *N*-methyl glucamine (Kabay *et al*. 2007); however, these adsorbents are expensive and none of them have been able to remove this pollutant from water at high initial concentrations (600 mg/l reported for some underground sources; Kabay *et al*. 2009) to standard values recommended in drinking water.

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