An analysis of boron removal from water using modified zero-valent iron nanoparticles

Hassan Khorsandi a, Aliye Azarnioush b,*, Ali-Ahmad Aghapour a, Sepideh Nemati b, Sima Karimzadeh b, Hamid-Reza Khalkhali c

aSocial Determinants of Health Research Center and Environmental Health Engineering Department, School of Public Health, Urmia Medical Sciences University, Urmia, Iran, emails: hassankhorsandi@yahoo.com (H. Khorsandi), aaghapour@gmail.com (A.A. Aghapour)
bEnvironmental Health Engineering Department, School of Public Health, Urmia Medical Sciences University, Urmia, Iran, Tel. +98 44 32752300; Fax: +98 44 32770047; emails: aliye.azarnoosh@yahoo.com (A. Azarnioush), nemati.sepid@gmail.com (S. Nemati), sima.karimzade@yahoo.com (S. Karimzadeh)
cBiostatistics and Epidemiology Department, School of Medicine, Urmia Medical Sciences University, Urmia, Iran, email: khalkhali@umsu.ac.ir (H.R. Khalkhali)

Received 15 August 2016; Accepted 12 January 2017

ABSTRACT

Considering the necessity of boron removal from water and its unexpected resistance against a majority of common processes, the use of efficient procedures for its removal seems more necessary than ever. Therefore, the aim of the present study is to analyze boron removal from water using zero-valent iron nanoparticles (nZVI) stabilized by two biopolymers. Modified nZVI was synthesized using the method of ferrous sulfate reduction. Structural features, chemical mixture, and morphological characteristics of selected nanoparticles (starch-nZVI [S-nZVI]) were confirmed by X-ray diffraction and scanning electron microscope. The function of S-nZVI in boron removal was examined under the influence of various factors including initial concentration of boron, S-nZVI dose, pH, and contact time in batch conditions. Boron was measured by the standard carmine method. The results showed that 1 mg/L of S-nZVI can reduce up to 20 mg/L of boron to less than its maximum allowable concentration in the pH of 8.5 and reaction time of 90 min. Kinetics of boron adsorption by S-nZVI follows pseudo-second-order ($R^2 = 0.999$) upon which adsorption capacity of boron by S-nZVI at equilibrium time fluctuates between 4.55 mg/g at initial concentration of 5 mg/L and 48.78 mg/g at initial concentration of 50 mg/L. Furthermore, boron adsorption by S-nZVI is more compatible with Langmuir isotherm ($R^2 = 0.93$). Accordingly, the maximum adsorption capacity of boron by S-nZVI was determined as 128.2 mg/g. Hence, as an appropriate, eco-friendly reactant, nZVI modified by starch can be used in boron removal from aquatic environments.

Keywords: Boron; Carboxymethyl cellulose; Starch; Water; Zero-valent iron nanoparticles

* Corresponding author.