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Removal of Pb(II) from aqueous solution by a zeolite–nanoscale zero-valent iron composite

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HIGHLIGHTS

- ▸ Zeolite/nZVI composite, a material for removal of Pb ion from aqueous solution.
- ▸ The removal of Pb(II) is largely depending on the solution pH and temperature.
- ▸ More than 96% of Pb(II) was removed by the composite within 140 min with 0.1 g composite.
- ▸ X-ray diffraction studies confirmed the reduction of some of the Pb(II) to Pb^0.

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ABSTRACT

The effectiveness of nanoscale zero-valent iron (nZVI) to remove heavy metals from water is reduced by its low durability, poor mechanical strength, and tendency to form aggregates. A composite of zeolite and nanoscale zero-valent iron (Z–nZVI) overcomes these problems and shows good potential to remove Pb from water. FTIR spectra support nZVI loading onto the zeolite and reduced Fe^0 oxidation in the Z–nZVI composite. Scanning electron micrographs show aggregation was eliminated and transmission electron micrographs show well-dispersed nZVI in chain-like structures within the zeolite matrix. The mean surface area of the composite was 80.37 m^2/g, much greater than zeolite (1.03 m^2/g) or nZVI (12.25 m^2/g) alone, as determined by BET-N_2 measurement. More than 96% of the Pb(II) was removed from 100 mL of solution containing 100 mg Pb(II)/L within 140 min of mixing with 0.1 g Z–nZVI. Tests with solution containing 1000 mg Pb(II)/L suggested that the capacity of the Z–nZVI is about 806 mg Pb(II)/g. Energy-dispersive X-ray spectroscopy showed the presence of Fe in the composite; X-ray diffraction confirmed formation and immobilization of Fe^0 and subsequent sorption and reduction of some of the Pb(II) to Pb^0. The low quantity of Pb(II) recovered in water-soluble and $Ca(NO_3)_2$-extractable fractions indicate low bioavailability of the Pb(II) removed by the composite. Results support the potential use of the Z–nZVI composite in permeable reactive barriers.

1. Introduction

Heavy metals are problematic for ecosystems because of their toxicity and most heavy metals can be highly toxic even at very low concentrations. Among these, Pb is commonly used in several industries and in some locations large amounts of wastewaters containing high concentrations of Pb ions have been released. Lead directly or indirectly reaches surface and ground water and becomes biomagnified in biotic communities. Lead primarily accumulates in muscles, bones, kidneys, and brain tissues and can cause anemia, nervous system disorders, and kidney diseases [1]. Conventional ion exchange, filtration, adsorption, chemical precipitation, and reverse osmosis are being used to remove metals from water [2]. Among these methods, adsorption is a highly efficient and economical removal technique [3].

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