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Removal of Pb(II) and Zn(II) from aqueous solution by ceramisite prepared by sintering bentonite, iron powder and activated carbon

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HIGHLIGHTS

- ▶ Fe_2O_3-ceramisite is prepared with bentonite, iron powder and activated carbon for Pb(II)/Zn(II) removal.
- ▶ The removal of Pb(II)/Zn(II) by Fe_2O_3-ceramisite was influenced by initial Pb(II)/Zn(II) concentration and solution pH.
- ▶ Fe_2O_3-ceramisite effectively removed Pb(II)/Zn(II) from aqueous solution by forming crystals containing Pb(II)/Zn(II).
- ▶ The maximum removal efficiency of Fe_2O_3-ceramisite for Pb(II)/Zn(II) was over 97%.

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ABSTRACT

Heavy metal pollution has become a major global problem, which threatens the environment and human life by its toxicity. Development of novel low-cost adsorbents for heavy metals removal has attracted great attention. In this study, bentonite, iron powder (IP) and activated carbon (AC) were used to prepare Fe_2O_3–ceramisite (FOC) by sintering at 800 °C. Effects of weight ratio of raw materials on physical properties of FOC including bulk density (BD), 1-h water adsorption rate (WAR), acid solubility (AS), BET surface area and average pore size (APS) were examined. Experiments were conducted to determine the factors affecting sorption of Pb(II) and Zn(II) on FOC including initial metal ion concentration, contact time and initial solution pH. Experimental data were tested using different kinetics models. Results revealed that: With an increase of AC rate, WAR, AS, APS and BET surface area increased linearly, while BD linearly decreased. Hematite (Fe_2O_3) was the main crystalline phase emerging in FOC, which promoted the removal of Pb(II) and Zn(II) by formation of Pb(II)/Zn(II)-containing crystalline phases in the reacted FOC. The cation-ion exchange reaction played an important role in the removal of Pb(II) and Zn(II). The pseudo-second order model was most applicable to describe the removal process of Pb(II) and Zn(II).

1. Introduction

Pollution of the natural environment by heavy metals is a worldwide problem since these metals are non-biodegradable and bioaccumulative, and many of them have toxic effects. Many industrial facilities such as metal plating, petroleum refining, tanneries, batteries, mining operations, electronic and chemical plants, pigments, alloys and fertilizer [1,2] discharge heavy metals via their waste effluents. Especially, effluents from extractive industries established over the last century are directly discharged onto surrounding land and surface water bodies constituting point and non-point sources of heavy metals contamination for groundwater. Mining operations are regarded as the significant source of heavy metal contamination of the environment owing to activities such as mineral exploitation, ore transportation, smelting and refining, disposal of the tailings and waste waters around mines.

Pb(II) and Zn(II) ions are frequently present in acid mine drainage wastewaters, which has received worldwide environmental attention, especially from regions like North Wales (United Kingdom) [3], Spain [4], Mexico [5] and China [6]. Pb(II) can result in behavioral changes, learning disabilities, reading problems, development defects, language difficulties, mental retardation, and abnormalities in pregnant women [7,8]. Despite an essential micronutrient for life, zinc can also lead to depression, lethargy, increased thirst and neurologic symptoms beyond the maximum acceptable concentration in living organism [9]. Hence, it is essential to remove Pb(II) and Zn(II) from wastewaters before migration and transformation into environment.

Currently, various physicochemical and biological strategies have been developed for the removal of heavy metals from wastewaters, such as chemical precipitation [10], electrochemical treatment [11], ion exchange [12], solvent extraction [13], zero-valent

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