Materials and Methods

Introduction

Lead is a ubiquitous trace metal cation in soils and sediments. Understanding the interaction of lead with mineral surfaces is important in determining its potential bioavailability. Potential bioavailability of trace metals is primarily controlled by adsorption/desorption reactions at the solid-solution interface. Previous research has demonstrated that the quantity and rate of trace metals desorbed from mineral surfaces decreases with an increasing residence time; altering the potential bioavailability. Several explanations have been proposed for the residence time effect including diffusion into the defects and fissures of mineral oxides.

Abstract

Experiments were conducted to examine the influence of adsorption residence time on the desorption kinetics of lead from goethite over a range in surface loadings (0.26, 0.63, and 1.89 * mol m$^{-2}$) at a pH of 6.0. Additionally, the long-term studies evaluated the influence of mixing. Short-term, long-term non-stirred and long-term stirred adsorption experiments were conducted for each surface loading. A miscible displacement technique was used to analyze the kinetics of lead desorption for the 9 studies as well as a sample (LT-5) from a previous study that has been equilibrating for 5 years. The short-term experiments were run in duplicate for 24 hours. Lead was desorbed by a 0.15 M solution of Ca(NO$_3$)$_2$. All experiments were run in duplicate for 24 hours.

Results

- Percent lead desorbed followed the order short-term > long-term non-stirred > long-term stirred. However, these differences were not statistically significant. Similarly, the difference observed between short-term and long-term (5 months) lead desorbed from the LT-5 were not statistically significant. However, when this sample was allowed to age for 5 years significantly less lead was desorbed compared to the short-term sample. These results suggest that the residence time effect observed by some researchers may be an artifact of the relatively short desorption time (≤8 h).
- The quantity of Pb$^{2+}$ released after the 8 h desorption period increased between 12 to 46% over that of the 8 h desorption period.
- The quantity of Pb$^{2+}$ desorbed after 5 y equilibrium period decreased by 64% compared to the 7 day equilibrium period.

Objective

Examine the influence of mixing and the length of the desorption period on the long-term desorption kinetics of lead from goethite.

Conclusions

- Mixing did not affect the long-term desorption of lead from goethite. Although there are differences between the stirred and non-stirred experiments, these differences are not statistically significant.
- The LT-5 sample did not have a significant difference between the short-term (7-day) and long-term (5-month) experiments (previous study).
- However, the sample was allowed to age for 5 years significantly less lead was desorbed compared to the short-term experiment.
- Shorter desorption times (<8 h vs. 24 h) may be responsible for the residence time effects observed by some researchers.
- Further research with longer adsorption periods, perhaps a number of years, is necessary to determine if residence time effects observed are an artifact of the length of the desorption period or experimental conditions.

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Adsorption isotherms were conducted at a constant suspension density of 0.26, 0.63, and 1.89 mol L$^{-1}$. Lead solution concentrations at suspension densities of 1, 2.5, and 5 g L$^{-1}$ goethite and a pH of 6.0. Three surface loadings representing a range in lead surface coverages were chosen to conduct adsorption and desorption experiments.

- A short-term (24-48 hours), long-term (6 months) non-stirred (LT NS), and a long-term (6 months) stirred (LT S) experiment were conducted for each of the surface loadings.
- Adsorption experiments were run using a batch technique; all experiments were conducted in a nitrogen environment in order to eliminate CO$_2$ contamination. After 24 hours the long-term experiments were poured into sample bottles and placed on an environmentally controlled rotating shaker (Non-Stirred experiments were placed on a shelf in the shaker.)

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Conclusions

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