The application of Fe–Mn hydrous oxides based adsorbent for removing selenium species from water

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HIGHLIGHTS

► The new material based on Fe–Mn hydrous oxides is an efficient selenium adsorbent.
► The adsorbent was more selective towards Se(IV) than Se(VI).
► A variety of operating parameters was tested in static and dynamic conditions.
► Extensive modelling of the experimental data illustrates the Se removal mechanism.

GRAPHICAL ABSTRACT

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In this study, the adsorptive removal of selenium(IV) and selenium(VI) from water by a newly developed ion exchange adsorbent, based on Fe(III) and Mn(III) hydrous oxides, was examined. This study was conducted to determine the influence of various operating parameters, such as initial anion concentration, contact time, adsorbent dose, pH, solution temperature, and the presence of competitive anions, on the treatment performance. The high Se(IV) adsorptive capacity of the adsorbent (up to 41.02 mg/g at pH 4) was due to its high affinity for selenite, as reflected in the fast rate of uptake (batch studies) and an efficient long-term removal (column experiments). Although adsorption of anions traditionally decreases as pH increases, the mixed adsorbent was capable of purifying large volumes of Se(IV)-containing water (at pH 7) to reach concentrations lower than 10 μg/L, which meets the European Commission standards. The presence of sulphate and carbonate did not influence Se(IV) adsorption. However, high phosphate and silicate concentrations may have decreased the removal efficiency of Se(IV). Data from the batch and column adsorption experiments were fitted with a number of approved models, which revealed the adsorption mechanism and allowed for a comparison of the results.

1. Introduction

The contamination of aquatic ecosystems with selenium is a major environmental issue. Selenium is an essential nutrient for humans and for all living organisms. However, the gap between the desired and toxic concentrations of selenium is narrow. Excessive amounts of selenium released into freshwater from mining, agricultural and petrochemical activities result in concentrations that are hazardous to aquatic environments [1].

Although selenium occurs in water in several forms, depending on its oxidation state, the predominant water-soluble anionic species include selenite (HSeO$_3^-$ or SeO$_2^{2-}$) and selenate (SeO$_4^{2-}$). Selenium is present in mildly oxidising and neutral pH environments. In addition, the selenite ion is more toxic and mobile in water than the selenate ion, which only exists at high pH and in oxidising conditions [2].