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Aluminum Impurities on Schwertmannite: Effects in Structure and Surface Properties

SERGIO CARRERO[1], JOAN GUTIÉRREZ-LEÓN[1], RAFAEL PÉREZ-LÓPEZ[2] AND JORDI CAMA[1]

[1]Institute of Environmental Assessment and Water Research (IDAEA)

[2]Universidad de Huelva

Presenting Author: Sergio.carrero@idaea.csic.es

Schwertmannite is a common nanomineral in acid sulfate environments (e.g. Acid Mine Drainage (AMD) and Acid Sulfate Soils (ASS) (Bigham and Nordstrom, 2019)). Its high and positively charged surface area results in a strong affinity towards toxic aqueous oxyanions such as arsenate (Carrero et al., 2017). These surface properties have been studied in synthetic and pure schwertmannite samples. However, natural precipitation of schwertmannite accumulates metal impurities (e.g. Al). Although Al incorporation in Fe-oxide minerals (e.g., goethite and ferrihydrite) has been reported (Cismasu et al., 2012), little is known about the Al incorporation effect on schwertmannite structure and surface properties. This process is relevant for schwertmannite that precipitates when circumneutral and acidic waters mix, increasing the pH and Al incorporation ion may be high.

In this research schwertmannite was synthetized with variable Al concentration in solution at pH ranging from 2.5 to 3.8. The Al-bearing schwertmannite samples were later used in As adsorption isotherm experiments at pH of 3.5. Solid samples before and after As adsorption were characterized using high energy X-ray diffraction (HEXD) and pair distribution function (PDF) analyses in order to (1) identify structural variations correlated with the Al content and (2) elucidate the retention mechanism of arsenate on the mineral surface. Results showed limited Al accumulation on schwertmannite with a strong pH-dependence. The arsenate sorption capacity observed in the Al-rich schwertmannite was similar to that of pure schwertmannite. However, PDF analysis revealed changes in the coordination mechanisms. Overall, the results obtained enable the prediction of metal(loid)s fate in environments affected by AMD and ASS, where physicochemical conditions allow aluminum incorporation in schwertmannite. New AMD treatment strategies could be explored to improve water quality and reduce contamination in areas with high ecological value.

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