Role of colloids on the (im)mobility of toxic elements in mine drainage systems with acidic and circumneutral pH

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Passive treatment systems are continually gaining popularity with regards to mine drainages due to their sustainability. Among other contaminants, pollution by heavy metals is prevalent and requires a detailed understanding of the systems to develop an effective wastewater treatment system. In passive treatment systems, some sequestration mechanisms include coprecipitation and adsorption, however, the significant factors controlling these processes may vary from system to system because of variations in geochemical properties. Therefore, this study clarifies the mechanisms that influence the attenuation behaviours of contaminants in two mine drainages of varying properties.
Ainai mine drainage and Shojin river have circumneutral and acidic pH respectively but are both high in Fe. The thermodynamic properties of Fe allow for the formation of Fe colloids that assist in the sequestration of these elements. In order to clarify the distribution of metals (e.g., As, Zn, Pb and Cd) in the drainages, the dissolved and colloidal fractions obtained from micro- and ultrafiltration were analysed. Despite the pH variations in Ainai (avg 7.1) and Shojin (avg 3.1), Fe colloid formation was observed in both systems. However, a detailed observation of the trends suggests that pH >3.1 may efficiently allow for colloid formation and toxic element sequestration. Trends of As were similar to those of Fe, indicating efficient sequestration by the Fe colloids. Pb and Zn are comparatively less sequestered due to competitive adsorption and pH dependence of the elements to be efficiently adsorbed. Hence, Pb and Zn were majorly present in dissolved fractions, despite the presence of LDH that partially reduced the Zn concentrations in Ainai mine drainage. Aggregation is observed in both systems which results in a deposition of the colloid aggregates and hence an efficient removal of Fe and As, and minimally, Pb and Zn from the mine drainages. This study demonstrates the significance of colloidal particles for the sequestration of metals and the significance of detailed characterisation of colloids in the environment.

