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Mineralogical attenuation for metallic remediation in a passive system for mine water treatment

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Abstract

Passive systems with constructed wetlands have been consistently used to treat mine water from abandoned mines. Long-term and cost-effective remediation is a crucial expectation for these water treatment facilities. To achieve that, a complex chain of physical, chemical, biological, and mineralogical mechanisms for pollutants removal must be designed to simulate natural attenuation processes.

This paper aims to present geochemical and mineralogical data obtained in a recently constructed passive system (from an abandoned mine, Jales, Northern Portugal). It shows the role of different solid materials in the retention of metals and arsenic, observed during the start-up period of the treatment plant. The mineralogical study focused on two types of materials: (1) the ochre-precipitates, formed as waste products from the neutralization process, and (2) the fine-grained minerals contained in the soil of the wetlands.

The ochre-precipitates demonstrated to be poorly ordered iron-rich material, which gave rise to hematite upon artificial heating. The heating experiments also provided mineralogical evidence for the presence of an associated amorphous arsenic-rich compound. Chemical analysis on the freshly ochre-precipitates revealed high concentrations of arsenic (51,867 ppm) and metals, such as zinc (1,213 ppm) and manganese (821 ppm), indicating strong enrichment factors relative to the water from which they precipitate.

Mineralogical data obtained in the soil of the wetlands indicate that chlorite, illite, chlorite–vermiculite and mica–vermiculite mixedlayers, vermiculite, kaolinite and goethite are concentrated in the fine-grained fractions (<20 and <2 μm). The chemical analyses show that high levels of arsenic (up to 3%) and metals are also retained in these fractions, which may be enhanced by the low degree of order of the clay minerals as suggested by an XRD study.

The obtained results suggest that, although the treatment plant has been receiving water only since 2006, future performance will be strongly dependent on these identified mineralogical pollutant hosts.

Keywords: Mine water, passive treatment, arsenic, metals, ochre-precipitates, clay minerals