A three-dimensional nanoscale study in selected coal mine drainage

Luis F. O. Silva; Tito J. Crissien; Celene Milanés; Carlos H. Sampaio

Abstract

Sediments from coal mine drainages (CMDs) contain large quantities of suspended pollutants (possibly numerous chemical substances) along with sulfates and hazardous elements (e.g., chromium, zinc, copper, lead) that irreversibly accumulate in the water. As this accumulation can continue for decades after discontinuation of coal extraction, it is necessary to employ multidisciplinary approaches to control the threat in such zones. The quantity of amorphous material in some CMDs was evaluated by X-ray powder diffraction (XRD) using the Rietveld-based SIROQUANT software package. Modern Dual Beam Focused Ion Beam (FIB), field emission scanning electron microscopy (FE-SEM), high-resolution transmission electron microscope (H-TEM), and energy-dispersive X-ray spectrometer (EDS) were used to evaluate the occurrence and transformation of nanophases (NPs). FIB is used to determine the 3D distribution of different species (internal structure) within individual NPs, whereas EDS is used to observe NP features (e.g., shape, constituent, range, assembly, and form of polymerization). The mineralogy of the sediment from the Brazilian CMDs, including the proportions of quartz, clays, Al–Fe-oxides, and amorphous NPs, appears to be related to the nature of the mineral matter in the relevant coal cleaning rejects (CCRs). The sediments of CMDs from the Brazilian coal area derived at a lower-pH range have different amorphous compositions as compared to those derived at a higher pH range. These special amorphous compositions are shown to be related to several other sediment properties such as particle surface area. The information gleaned in this study will be useful for further geochemical evaluation of CMDs in other parts of the world.

Keywords: Multi-analytical approach; Non-destructive techniques; Potential impacts diagnosing; 3D nanoparticles study