Battelle Proceedings

Assessing Geomaterials and Waste Products for Potentially Toxic Elements Retention in Acid Mine Drainage from the Iberian Pyrite Belt, Southwest Portugal

Joana Araújo (jfaraujo@uevora.pt)**,** Rita Fonseca (rfonseca@uevora.pt), Roberto Silva (rper.dasilva@gmail.com) (University of Évora, IES, Évora, Portugal)
Teresa Valente (teresav@dct.uminho.pt) (University of Minho, IES, Braga, Portugal)

Conference

2025 Sediments Conference

Session

Part of - In Situ Treatment Amendments

Track: D6. In Situ Treatment Amendments

Background/Objectives

The Iberian Pyrite Belt (IPB), dating back to the Devonian Period, is a volcanic-sedimentary complex extending across the Iberian Peninsula. It encompasses several major volcanogenic massive sulfide ore deposits. Located in southern IPB, Portugal's Grândola region, the Caveira Mine is an abandoned ore deposit rich in Cu, Pb, Zn, Ag, and Au. Historically exploited from Roman times until the 1960s, the mine was abandoned with approximately 2 Mt of oxidizing sulfide-bearing waste, leading to important environmental degradation through erosion, leaching, and diffusion. These processes contaminate downstream sediments with high concentrations of Potentially Toxic Elements (PTE), while low pH values in these sediments and watercourses indicate ongoing acid mine drainage (AMD) generation. Thus, the primary objective of the present study is to develop an effective, low-cost remediation strategy using geomaterials and waste products to mitigate AMD impacts on sediments.

Approach/Activities

We evaluated the efficacy of 12 low-cost materials (including carbonated powders, ferruginous soil, iron oxides, clay minerals, cellulose sludge, biochar, and activated carbon) at a laboratory scale to determine their PTE retention capacities. Each material underwent geochemical characterization to assess its chemical composition and labile forms. Efficacy testing comprised kinetic experiments with mono-elemental solutions at pH 5.5, representing the worst-case PTE concentrations, and a pond simulation using a composite water sample from the

mine reflecting critical PTE concentrations (pH 1.64). For the kinetic tests, materials were exposed to defined metallic concentrations (10 g/L) in an orbital shaker at 225 rpm and room temperature, with samples collected periodically over 24 hours for ICP-OES analysis. In the pond simulation, conducted over 10 days, mining water was added to each material in varying ratios (1:50, 1:100, 1:200), under aerobic and anaerobic conditions, with daily monitoring of pH and Eh levels. Post-simulation, water samples were filtered and analyzed via ICP-OES, and materials were tested for exchangeable PTE forms using ammonium acetate at pH 4.5.

Results/Lessons Learned

Cellulose sludge demonstrated the highest retention efficiency in kinetic tests, achieving over 90% retention for all analyzed PTE except Hg, which was only retained by activated carbon (>94%). The pond simulations indicated no significant efficacy difference between aerobic and anaerobic setups; thus, an open pond system is preferred for cost-effectiveness. Carbonated materials significantly increased water pH, reaching a maximum value of 6.23, facilitating Fe precipitation and improving PTE retention. The optimal material-to-water ratio was found to be 1:100.

The best retention values were found in carbonated materials and clays, such as bentonite. This study suggests that the best remediation approach is sediment capping with bentonite / carbonated materials and Fe-oxides (for As) preceded by an open pond with cellulose sludge or carbonated materials at the bottom for previous neutralization.

Publisher: Battelle