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Application of indigenous limestones for the removal of As and heavy metals from acid mine drainage

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In Mexico, acid mine drainage has polluted soils and water with potentially toxic elements (PTE′s) at many historical mining zones. Tailings that were deposited without environmental protection measures constitute still a source of As and heavy metals. To solve this problem, there is an urgent need of affordable and sustainable solutions. Limestone was evaluated as a low-cost alternative to build geochemical barriers since carbonate-hosted Ag-Pb-Zn deposits occur in an important area of the Mexican territory. Column experiments were performed with AMD solutions produced from water interaction with tailings from an oxidized old (CMZ) and a currently operating (SMN) less weathered deposits at Zimapán, Mexico. Cretaceous limestone rocks were collected from outcrops near the tailings zone, crushed and ground. Four transparent acrylic columns 50 cm length, 10 cm width with five sampling ports at 10 cm distance were filled with the rock particles and fed with AMD delivered by a peristaltic pump. Leachates were collected from the bottom and at each port along 14 weeks (for CMZ) and 20 weeks (for SMN). Rocks were chemically and mineralogical characterized (XRF, XRD,) before and at the end of the treatment period. Besides, precipitates formed over the limestone particles were characterized by SEM-EDS and SEM-WDS. Conductivity, pH and Eh were determined, and Cd, Zn, Pb, Al, FeT, Fe(II), Ca, As, SiO_2 and SO42- analyzed, in column leachates by atomic absorption spectrometry (flame and hydride generation), UV-visible spectrophotometry, and titration. Results showed that As, Fe, Al and Cd contained in leachates produced from the highly weathered and the recent tailings were almost totally retained in the columns. However, an additional treatment would be necessary to remove Zn. Precipitation of minerals and adsorption on hydrous ferric oxides (HFO) and calcite retained the PTE's by the formation of As-HFO, As-calcite, Al-SiO_2, Zn-HFO, Zn-$CaCO_3$ or $ZnCO_3$ and probably Cd-HFO and Cd-$CaCO_3$ or $CdCO_3$. While HFO is considered a problem by the reduction of hydraulic permeability, it plays a relevant role on As and heavy metals retention. Alternatives should be developed to use other materials to improve permeability. Successful performance indicated that this treatment system may be applied in highly oxidized tailings and also to prevent AMD dispersion in tailings with oxidation in progress, representing a cost-effective option by lowering expenses in raw material and transportation in areas with limestone outcrops.