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Hydrochemical performance and mineralogical evolution of a dispersed alkaline substrate (DAS) remediating the highly polluted acid mine drainage in the full-scale passive treatment of Mina Esperanza (SW Spain)

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Abstract

Acid mine drainage remediation is an unresolved matter in abandoned mining districts around the world. Development and implementation of passive treatment systems in these areas are commonly focused on engineering and water quality aspects. Neoformed mineral phases precipitated within the reactive material of these passive treatments account for the removal of pollutants but also can cause clogging and passivation of the reactive substrate. After 20 months of operation and monitoring, the limestone-based passive treatment system implemented in Mina Esperanza (SW Spain) was sampled to study the relationship between water chemistry, mineral composition of the neoformed precipitates, and treatment performance. Water chemical profiles show the existence of three precipitation zones controlled by Fe, Al, and Zn hydrochemistry and also a migration with time of precipitation zones downward into the reactive material. These precipitation zones were also confirmed by a mineral study performed on the solid samples where either schwertmannite and goethite or hydrobasaluminite and Zn-rich green rust were the mineral phases that controlled the metal removal in the three precipation (Fe, Al, or Zn) zones. Iron and Al precipitates were observed to play a critical role in the time evolution of the reactive material hydraulic conductivity. Furthermore, Al precipitates passivated to some extent the limestone grains by armoring, although migration of the Fe precipitation zone and Al redissolution later activated the limestone grains. A higher proportion of limestone in the reactive mixture and the addition of new reagents to the bottom section of the reactive material (to enhance the reducing environment and to promote divalent metal removal) are proposed on the basis of this hydrochemical and mineralogical study for a future design for the Mina Esperanza passive treatment system.

Keywords: Acid mine drainage, passive treatment system, schwertmannite, hydrobasaluminite, green rust