Passive removal of Mn from mine water by heterogeneous Mn oxidation[1]

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Abstract: Manganese ($Mn^{2+)}$ is a common water contaminant at coal and metal mining sites world-wide. At most international mine sites, the effluent limit for Mn is 0.5 mg/L. At U.S. coal mine sites, the standard effluent limit for Mn is 2.0 mg/L, however there are efforts underway in Pennsylvania to lower the limit to 0.3 mg/L. The standard treatment of Mn involves caustic chemicals that are expensive, hazardous, create non-target solids ($Mg(OH)_2$, $CaCO_3$), and can result in violation of pH effluent limits. Passive treatment of Mn, which 25 years ago was considered economically infeasible, has evolved to a reliable and cost-effective alternative to chemical treatment. This presentation will describe passive treatment of Mn using data from several systems installed at coal and metal mine sites. The removal of Mn in chemical systems is through a homogeneous oxidation reaction that has very slow kinetics at pH less than 10. In passive systems Mn is removed by a heterogenous oxidation process that occurs within the bicarbonate buffering system at pH 6.5 – 7.5. Mn^{2+} is adsorbed to a solid where it is oxidized by dissolved oxygen. The surface can be a variety of materials, but the primary sorbing-solid in passive systems is previously precipitated birnessite (MnO_2). Bacteria may also contribute to the oxidation. The typical substrate for passive Mn-removing systems is aggregate whose selection is based on the acidity of the water and local availability. Systems has been built with limestone, dolomite, and granite. The presentation will explain the requirements for the heterogenous Mn oxidation process and present results from installed passive systems at coal mines in the eastern U.S. and metal mines in Brazil, Laos, and Vietnam. The passive systems treat a range of flow rates (40 – 1,200 gpm) and influent Mn concentrations (1 – 30 mg/L). All systems lower Mn to concentrations consistent with permit or restoration targets. The results indicate that compliance with lower effluent Mn limits being considered in the U.S. is feasible with a passive treatment process.

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