Physicochemical and microbiological mechanisms of metals removal during passive mine water treatment at low and circumneutral pH

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Abstract

Results from two studies on the treatment of low pH metal mine water and circumneutral coal mine water are presented. These involve using vertical flow mine water treatment systems where mine water is directed through a unreactive gravel bed to encourage metal removal under aerobic conditions. This study highlight previously under-reported physicochemical and microbiological mechanisms responsible for the removal of iron at low pH, and manganese and trace metals at circumneutral pH. These mechanisms can be harnessed for the passive treatment of acidic and circumneutral mine water and have implications for the biogeochemistry of mine sites and transport of metals in the environment. At the low pH site (~pH 2.9), significant removal of iron, as high as (85%) was shown in vertical flow system, the mechanism is thought to be removal predominantly by the crystal growth and/or aggregation and filtration of nanoparticulate Fe(III). Centrifugation indicates that $Fe(III)_{(s)}$ present are < 35nm. Also microbial Fe(II) oxidation and bioprecipitation of Fe(IIII) is important at times. The circumneutral site data shows manganese removal at high rates can be achieved by contacting iron and manganese bearing mine water with an accreting bed of ochre. The vertical flow of Fe(II) and Mn(II) -bearing water through an accreting bed leads to spontaneous formation of Fe/Mn banding structures in the ochre bed and also leads to the removal of other contaminants of concern notably thallium and cobolt, with ochre from the vertical flow system being demonstrably enriched in these elements compared to settling lagoon ochre from the same site. The use of vertical flow reactors represent an attractive option for (i) the removal of iron from low pH mine water without the requirement for any pH adjustment, and (ii) removal of iron and manganese and trace metals from circumneutral mine water.