Treatment of acid mine drainage (AMD) using iron oxides

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Abstract

Synthetically prepared iron ferrite and the mineral magnetite are very effective for the removal of heavy metals from AMD. Iron ferrite can be utilized in a batch mode by adding preformed ferrite to the solution or by preparing the ferrite in situ using the iron in the water. Natural magnetite can also be used in a batch mode, or better, in a column mode. The loaded magnetite can easily be regenerated using a regenerating solution and the metals recovered if desired. This paper will review previous laboratory studies using the process on various AMD sources in Colorado containing various amounts of Al, Cd, Cu, Fe, Pb, Mn, Se and Zn, and give details of a pilot plant experiment.

In the laboratory studies, selenium (10 mg/L) removal using ferrites and magnetite (2 wt%) removed over 99% of the selenium, and the magnetite experiments showed the best removal of selenium. However, in the uranium studies (using 2 wt% adsorbent and 30 ppm U feed), uranium recoveries greater than 98% were observed with iron ferrite compared to magnetite, and batch experiments out performed column operations; effective elution of the uranium with bicarbonate solution for reuse of the sorbent appears possible.

The effect of pH and amount of magnetite on contaminant removal from various mine water samples was studied (Proceedings of the International Mine Water Conference, Pretoria, South Africa, October 19-23, 2009). Varying amounts of magnetite had minimal effect on metal removal. Experiments were performed at various pH values to remove the major metal contaminants. Generally, complete removal of copper, iron and zinc occurred at pH 6–8, and manganese was effectively removed at pH 10. Experiments at pH of 1–3 showed that there was insignificant metal sorption occurring on the magnetite, confirming the ability to strip the loaded sorbent with pH 1–3 water to recover the metals and reuse the sorbent. In situ ferrite was also tested on some of the mine waters, and all the primary metals of concern were effectively precipitated at a pH greater than 9.

In the pilot studies, AMD containing 400 mg/L Al, 1.6 mg/L Cd, 6.8 mg/L Cu, 25 mg/L Fe, 1.2 mg/L Pb, 45 mg/L Mn, 10 mg/L Se, and 48 mg/L Zn was continuously fed to the system for 4 days at a rate of 250–450 mL/min. The process had an initial tank for conditioning and magnetite or recycled ferrite addition. The second tank included aeration and addition of small amounts of lime to maintain pH ~10. The last two tanks provided ferrite formation/maturation and settling, respectively. The final step of the process was passing the effluent through a column of magnetite and filtration. Ferrite or magnetite was reused throughout the pilot. Effective metals removal rates were observed with a retention time of as little as 27 minutes. Metals in the effluent were below target treatment standards except aluminum, cadmium, and lead. In all cases, the effluent contained <400 μg/L Al, <10 μg/L Cd, <5 μg/L Cu, <100 μg/L Fe, <50 μg/L Pb, <100 μg/L Mn, <50 µg/L Se, and <30 µg/L Zn. Filtered sludge volume was reduced by as much as 49% over lime precipitation. Sludge transportation and disposal costs are estimated to be ~6% lower with ferrite-magnetite than with conventional lime treatment and estimates for capital and operating costs are about 10-15% lower.

Keywords: iron ferrites, AMD treatment, magnetite, wastewater treatment