Waste or Resource? Extraction Potential from Acid Mine Drainage for Useful Resources

D. Kirk Nordstrom

US Geological Survey, Boulder, Colorado, USA
dkn@usgs.gov

Extended Abstract

Acid mine drainage could be a source of hydrogen, metals, and gypsum for energy and com-mercial products. For example, discharge from the Richmond Tunnel at Iron Mountain, California and the Reynolds adit at the Summitville mine, Colorado, each release between 30 and 200 metric tons per year of dissolved copper. For the period of 1994-2002, an estimated $6 million in copper and $14 million in iron was discharged from Iron Mountain. Instead of treating this drainage water with lime or limestone to produce an uneconomic sludge, the copper and other metals could be recovered and recycled into resources for commercial products. Currently a low-iron water near Breckenridge, Colorado, produces about 40,000 kg/yr of zinc by precipita-tion with sulfide and the insoluble material is shipped to a smelter to enrich the feed in zinc for better recovery. A demonstration plant removing high-purity gypsum from contaminated groundwater at a mining site in Arizona has been operating for more than 5 years. In China, removal of copper from an acid mine water by sulfide precipitation has also been found to be viable. The challenge is (1) to separate the valuable components from each other in a manner that is efficient and economically viable, (2) to stockpile components in an environmentally safe manner, and (3) to transport the separated components to an industry that can use them as source material for production. Every site must be assessed individually to ascertain what types of extraction, stockpiling, and transport are most appropriate.

Extraction techniques cover a wide variety including electrochemical, microbiological, evapora-tion, precipitation, solvent extraction, ion exchange, and reverse osmosis. Many of these techni-ques have been tried before with variable and usually limited success either from an economic or technical perspective. However, from the point of view of getting aqueous contaminants out of the environment and into recycled production, these technologies may be considered effecti-ve. With considerable emphasis on sustainable practices today, these techniques need to be evaluated and re-evaluated, improved, and further developed both alone and in combination for inactive and active mine sites.

Electrochemical techniques offer considerable versatility but can suffer from competing electro-de reactions and high energy demands depending on the type of cells used. Copper cementa-tion, which takes advantage of spontaneous electrochemical replacement of scrap iron by copper, is a very old, efficient, and inexpensive technique that could be used at Iron Mountain and Summitville and many other mine sites without applying electrical current. At many mine sites, tailings and/or waste-rock pile leachates could be run through a copper cementation or solvent extraction plant. With the application of current in specially designed electrochemical cells, hydrogen gas can be obtained as well as selective removal of metals depending on pH and composition of the solution. Fuel cells can be built based on iron oxidation and oxygen reduction.

Microbial bioreactors have been built for sulfate reduction to produce aqueous sulfide which can be used to precipitate metal sulfides. Recent investigations have shown that microbial sulfate reduction can be accomplished at relatively low pH (circa 3–4). The metal sulfides can then be transported to smelters for metal recovery. Bioreactors also oxidize dissolved ferrous iron and precipitate ferric iron. With careful control of pH, sulfate concentration, and ratios of ferrous to ferric iron, different iron phases can be precipitated that include schwertmannite, jarosite, goethite, and magnetite with variable recovery of other metals. In Canada, microbial degradation of thiocyanate and of the resulting ammonia and nitrate is working efficiently on a large scale to remove toxic components from gold extraction to meet regulatory discharge requirements.

New techniques combining electrochemistry and microbiology such as microbial electrolysis of water are opening up new avenues for potential application. This process of biocatalyzed electrolysis produces hydrogen at much lower applied voltages than normally required.

Every wastewater needs to be carefully considered with respect to the components that need to be removed, their marketability, and the energy and storage requirements. For each waste-water there may be an optimal sequence of extraction techniques that benefits the industry and the environmental concerns.

For inactive mines, the capital outlay for an optimal design could be expensive and difficult to fund but at least some return on the finances could be realized rather than the current situation of substantial remediation costs with no return of capital. However, for active or planned mines, resource-recovery techniques could be introduced earlier to decrease environmental contami-nation, provide an additional source of income, and reduce future liability.

Key words: Acid mine water, resource recovery, extraction