TECHNOLOGY OVERVIEW

AERATION TREATMENT SYSTEMS

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1. INTRODUCTION

The reduction of dissolved metals concentrations in mining-influenced water (MIW) is typically a key component in cleanup and management strategies at current and former mine sites. Aeration is an active water treatment process component used to enhance reduction of certain dissolved metals concentrations in MIW under specific geochemical conditions. Aeration is often applied in conjunction with acid-neutralizing agents (lime, limestone, caustic soda, soda ash), chemical oxidants (ozone, sodium hypochlorite, hydrogen peroxide, potassium permanganate), flocculants, filtration, and settling basins.

Aeration involves the mechanical introduction of oxygen into the MIW stream through a variety of techniques with the goal of oxidizing dissolved metals species into less soluble forms. Aeration uses gravity and/or mechanical devices to increase the concentration of dissolved oxygen in MIW, promoting oxidation of iron, manganese, arsenic, and other problematic metals species, increasing treatment effectiveness and efficiency, and decreasing remediation costs.

A variety of aeration technologies exist, ranging from simple gravity-driven cascading flumes to in-line systems that use Venturi-based jet pumps to inject oxygen into the MIW (INAP 2009). Aeration is commonly applied simultaneously with addition of lime and flocculant to increase pH, oxidize metals species, and precipitate metal hydroxides that are then treated through settlement, filtering, or other processes.

2. APPLICABILITY

Aeration is applicable to the following situations:

- MIW discharge containing elevated dissolved metals concentrations, with low natural dissolved oxygen
- wide variety of sites suitable for active treatment technologies
- wide range of flow conditions
- used in conjunction with other metals and neutralization treatment technologies

Aeration is most commonly used for the treatment of MIW containing levels of dissolved metals that exceed regulatory or risk-based water quality standards. MIW often has low pH and low dissolved oxygen content and may contain elevated carbon dioxide (CO_2). In addition MIW commonly contains elevated levels of iron (Fe^{2+}), manganese (Mn^{2+}), and other metals that are mobile as dissolved constituents. The introduction of dissolved oxygen through aeration results in oxidation of the metals species into less soluble forms. Where elevated levels of CO_2 are present in MIW, aeration reduces the dissolved CO_2 content, thereby increasing the pH.

Aeration techniques can be engineered to treat a wide range of flow conditions, including sites with very high flow rates and sites with highly variable flow rates. The website at gardguide.com/index.php?title=Chapter_7#7.5.1_Active_Treatment_Technologies (INAP 2009) provides examples of various techniques for application of aeration with and without other treatment.

3. ADVANTAGES

The advantages of aeration include the following:

- simplicity and effectiveness of the fundamental geochemical process
- application flexibility
- the use of air as the treatment reagent
- wide range of site conditions
- wide range of flow conditions

Oxidation reactions are straightforward and readily occur when oxygen is introduced into low-oxygen MIW containing reduced metals species. Mechanical aeration is an effective and relatively inexpensive method for introducing oxygen. Depending on the contaminants being addressed, pH adjustment may be necessary in addition to aeration to achieve the desired oxidation reaction.

Aeration technologies can be adapted to a wide range of site conditions, making them suitable for remote sites as well as active and/or easily accessible mine sites. Aeration most commonly uses atmospheric air as the treatment reagent, avoiding the permitting, management, handling, and disposal issues that may apply to other chemical reagents.

4. LIMITATIONS

Aeration introduces oxygen into MIW and is, therefore, applicable to sites with MIW discharge containing elevated, dissolved, reduced metals species concentrations with low natural dissolved oxygen. Sites where MIW has relatively high oxygen content will not benefit appreciably from aeration technologies. Aeration has use as a sole remediation technology in limited situations, but is much more commonly applied in conjunction with other technologies.

5. PERFORMANCE

No performance data specific to aeration technologies were identified for this technology overview. Aeration is sometimes applied alone but is most commonly applied in conjunction with other treatment technologies to achieve regulatory or risk-based water quality standards. An example system described by EPA (2004) is the In-Line Aeration and Neutralization System, which uses a jet pump or eductor to entrain the air and alkaline chemical by Venturi action and a static mixer. Sodium hydroxide or sodium carbonate is added to the MIW with aeration to create flocculation. The flocculant is directed through a static mixer, to a clarifier, and then to settling ponds.

At the Leviathan Mine Case Study in California, a proprietary technology, Rotating Cylinder Treatment System (RCTS), was used to treat MIW drainage overflows from containment ponds on site during high spring runoff conditions at a rate of 30–300 gallons per minute. The MIW was acidic and contained high concentrations of sulfate and metals, including aluminum, arsenic, cadmium, copper, iron, manganese, nickel, selenium, and zinc. The process involved the use of aeration and lime neutralization to oxidize and precipitate the metals and treat 3 million to 20 million gallons of MIW annually.

The report for the RCTS indicated results for delivery of 9 pounds of oxygen per horsepower-hour and that mechanical surface aeration and submerged turbine aeration deliver 2–3.5 pounds of oxygen per horsepower-hour. The system treated 28 million liters over 85 days at average rates of several hundred liters per minute and a maximum rate of 2800 liters per minute (Tsukamoto n.d.).

As an active treatment method, aeration requires some level of ongoing operations, maintenance, and monitoring and a source of energy (gravity or electrical power) using infrastructure and engineered systems (INAP 2009). However, the level of operations and maintenance and power consumption covers a wide range. Simple gravity-driven flume systems may require infrequent maintenance and no electrical power. In-line systems can be designed to operate using excess systemic water pressure from an existing treatment plant. Otherwise, they can be designed to require little additional electrical power. As such, aeration systems are applicable to a wide range of mine site locations, ranging from remote sites with limited or no power, to active mining operations with comprehensive power infrastructure and labor resources.

6. COSTS

No cost information specific to aeration technologies was identified for this technology overview. Aeration costs are primarily associated with capital costs for system design and construction and energy costs and sludge management during operation. Gusek and Figueroa (2009) noted that costs for acid-neutralization technologies, which may be applied in conjunction with aeration, are on the order of several dollars per thousand gallons of treated water. Treatment chemicals can account for one- to two-thirds of the treatment costs. The use of aeration may reduce treatment costs, since the quantity of treatment chemicals is reduced due to the technology using atmospheric air.

7. REGULATORY CONSIDERATIONS

Aeration technologies do not add unique additional regulatory considerations than would be otherwise applicable to other MIW technologies. Because aeration typically uses atmospheric air as the reagent, there are no reagent permitting, management, handling, and disposal issues that may apply to other chemical reagents.

8. STAKEHOLDER CONSIDERATIONS

Aeration technologies are not expected to add unique additional stakeholder considerations that would not be otherwise applicable to the other MIW technologies being applied at the site.

9. LESSONS LEARNED

Aeration technologies can be a cost-effective addition to MIW treatment to enhance oxidation and solubility reduction for metals species in MIW. The addition of aeration to other MIW technologies can reduce chemical reagent use and costs. Developments in aeration technology, such as the RCTS, can improve oxygenating efficiency, thus reducing energy costs.

10. CASE STUDIES

Table 10-1. Case study including aeration technology

Leviathan Mine, CA

11. REFERENCES

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