

Topic PT-3

White Paper Topic: Passive Treatment-Improved Methods Development

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Background:

The vertical flow pond (VFP) has emerged the passive treatment system of choice for many of the mine drainage discharges throughout the Appalachian Region. The VFP consists of a layer of compost over a layer of limestone in a single pond. In theory, the VFP should function as a reaction vessel with metal deposition occurring in ponds and wetlands located beyond the VFP. However, in practice the VFP serves as a depositional vessel as well. Unfortunately, metal precipitates cannot be removed effectively from the VFP without near complete exhumation. As a result, many of the VFP's have or will fail prematurely and operation and maintenance of these systems tends to be much more labor intensive than originally intended.

Discussion:

In a typical VFP, the purpose of the organic layer is to reduce any ferric iron to ferrous iron and to strip the dissolved oxygen as the AMD passes through. In the ferrous form, iron should not form a precipitate within the VFP. Intended as a reducing zone, sulfate reduction and consequent alkalinity generation should occur in the organic layer. Next, the AMD enters a layer of limestone where dissolution of the limestone results in an increased pH and alkalinity, allowing for the future precipitation of precipitates.

A number of VFP's have been studied in detail and the chemical reactions that do or do not occur are becoming better understood as well as the conditions under which these reactions take place. Most of the VFP's, especially those treating large flows, do not function completely in accordance with the theory. Although not universal, here are some of the problems with the VFP's.

1. The conversion from ferric to ferrous was found to be seasonal...good conversion in the summer and poor conversion in the winter.
2. In some VFP's studied, a high percentage of iron is being retained in the VFP, often in the form of an iron hydroxide or iron sulfide that can plug the compost.
3. In VFP's where the organic layer is strictly compost, sulfate reduction is highly limited and often occurs only at the bottom of the layer near the limestone interface. Sulfur reducing bacteria require a pH of close to 5 in order to thrive.
4. If aluminum is present within the AMD and the pH is raised to around 4.5, it immediately forms a precipitate that tends to be retained within the VFP. Flushing systems have been installed within the limestone layer to allow for manual flushing of the precipitates from the limestone bed. Several of these flushing systems have gotten quite elaborate and require extensive piping and several water control valves. Data indicates that flushing removes only a part of the Al precipitate, and treatment deteriorates even with flushing.
5. Short-circuiting also is a problem in some VFP's.

Being a stubborn lot, many designers cling to the VFP concept and have engineered hybrid VFP's in an attempt improve on performance and longevity. Some of these hybrids, such as the addition of extensive flushing systems, have improved performance, but have also increased operation and maintenance obligations.

Separating the systems into individual components may be a way to go. For instance, PA BAMR designed a limestone upflow pond with an automatic flushing siphon to deal with aluminum in discharges. The limestone amended organic substrate system of R. C. Thomas sets up the proper conditions for sulfate reduction to occur and shows promise. Basically, we need to feel that we are not constrained by existing designs and start anew.

Action Needed:

We can no longer afford to continue to construct passive treatment systems that are doomed for failure. At this point in time, many studies have been conducted on constructed VFP's and there is a fair understanding what works and what fails. It is now time to engineer systems for success and minimal operation and maintenance. Based on chemistry and flow conditions, we can predict with a fair amount of certainty the chemical changes that will occur when the drainage is subject to different reagents, such as compost or limestone. We also have a fair understanding of how to enhance the removal of metal precipitates. Armed with this knowledge the following actions are proposed:

1. Characterize discharges into several subsets based on chemistry, concentration and flow
2. Determine the chemical changes that will occur with each subset when subjected to the various components used in passive treatment systems.
3. Develop a flow chart that will guide the designer to the most effective system based on existing conditions and develop proper design criteria for each system.
4. Develop new approaches and new technology to deal with the more difficult AMD discharges by passive or semi-passive methods.

In summary, funds and encouragement are needed to promote research and development of new and improved methods for passive treatment.

Project Cost:

The development of the flow chart is anticipated to cost about \$20,000 for compilation of data and assembling a group of experts. Development and testing of new approaches will be much more expensive. Funding of several projects at levels of \$100,000 or so should be anticipated.

Time Table:

The flow chart should be developed in a period of 6 months to 1 year. New approaches will probably require several years for pilot tests followed by full-scale systems.

Literature Survey:

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