Topic PT-1

White Paper Topic: Passive Treatment - Long-term Performance Evaluation and Metrics

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Background:

Passive treatment systems for acid mine drainage, including wetlands, anoxic limestone drains, vertical flow ponds (SAPS), and other methods, are being used extensively to treat acid mine drainage from coal mines. An estimated $50,000,000 of federal and state funds have been spent on these technologies in the last 15 years, and additional systems are being added every year. Therefore, we need good methods of evaluating the performance of these systems and determining their performance over their design lifetime of 10 to 25 years.

Performance of passive treatment systems is known to deteriorate with time, yet most performance analysis occurs on a single point in time, usually in the first year after construction, or a few samples in the first year, and on one or a few samples at a later date. The lack of complete temporal data leads to incorrect appreciations of their real performance.

Also, many different parameters are used to evaluate performance. Common measures of performance include removal of acidity, Fe, and Al in mg/L, percent removal of these constituents, load removal in mg/day of acidity, pH of effluent, alkalinity of effluent, cost per unit of acidity removed, macroinvertebrate communitiy in the receiving stream, and many other parameters. As a result many performance assessments are incompatible among authors and quantitative comparison of systems is nearly impossible. An additional area of concern is the inclusion of qualitative environmental benefits in evaluation, such as improvement of aquatic biota or aesthetic qualities.

Objective:

Development of a protocol for assessing passive treatment system performance over time that will yield useful quantitative results for the public, managers and researchers. Also, application of this protocol to a significant number of systems to provide information on the long-term performance of the technologies.

Approach:

A first step would be assembling a committee of knowedgable experts in passive treatment, This committee would evaluate the available metrics and procedures and develop a simple monitoring and evaluation protocol that could be applied to a wide variety of project evaluations. The results of this appraisal would be transferred to the designers, researchers, constructors and funders of passive treatment systems, with the recommendation that this type of data be collected on the systems they build or maintain.

Metrics for system evaluation should consider the (1) decline in AMD severity as indicated by changes in concentration and loading within system (performance); (2) changes in hydraulic capacity of permeable substrates; (3) variability of performance as function of flow rate, porosity, and associated detention time; (4) capacity of media for sustained treatment, including media consumption rate and reduction of contact between media and AMD associated with consumption, armoring, or clogging; and (5) cost and reliability of treatment on a unit basis-- per gallon (detention time), per ton (acidity load), per square meter (sizing, siting), etc. Consideration also may be given to systems that minimize exposure of humans or animals to accumulated contaminants (underground vs. above ground) or toxic reagents and general ease of system maintenance/replacement.
Critical parameters include flow rate, pH, "hot" acidity, alkalinity and calcium (to compute Pco2, calcite saturation, limestone dissolution rate), and concentrations of typical AMD metals and sulfate. Specific toxic constituents such as selenium or arsenic also may be of interest.

Parameters such as temperature could be important for the evaluation of rates of reaction and possible negative effects to "cold-water" ecosystems.

A second phase would be to apply the developed protocol over multiple years to collect a database on a representative set of systems. Also, watershed and similar groups could use this data in applying for funds for maintaining or rebuilding systems. Much of the data collection could probably be done by local groups, especially if analytical funds could be furnished, but provision for a program of collecting data is also desirable. The data should then be compiled into a database and shared with other investigators and researchers to improve designs and to evaluate funding priorities.

Metrics:

Many parameters are available and can be classified into chemical, physical, biological, design, temporal and cost parameters:

- chemical parameters: concentration or loading of acidity, alkalinity, Fe total, Fe 2+, Fe 3+, Al, Mn, pH, conductivity, SO4, Ca, toxic elements,
- physical parameters: flow, temperature, porosity, retention time, hydraulic head and gradient
- biological parameters: species identity and number, habitat, diversity, utilization by rare or threatened species, reproductive sink or source (recruitment)
- design parameters: system layout, sizing, reagents: limestone, organic matter, etc.
- temporal parameters: sampling intervals, total evaluation period
- cost parameters: total system costs, monitoring, maintenance and rebuilding costs.

Develop Evaluation Protocol:

Using a subset of the above metrics, develop a set of simple evaluation metrics. These might include:

- Dollars per ton of acid load removed at year X
- Dollars per ton of Fe load
- Change in loading of receiving stream
- Change in benthics of receiving stream

Schedule:

Within three months, develop draft protocol for presentation to ADTI CMS. With iterations and revisions this should be completed within 9 months. This protocol should be presented and discussed at one or more meetings of professionals in the field.

The second phase of compiling ling-term data is probably best accomplished by a continuing research group, such as OSM or the National Mine Land Research Center, who would continue to collect this data on a periodic basis and periodically disseminate the results to the profession.

Budget:

$30k for the development of a protocol, and $20k/year for at least a 5-year period for the continuing compilation.

Literature Survey:

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