Successful Passive Treatment of Iron-Rich Lead-Zinc Mine Waters and an Effective Method to Address Nuisance Constituents

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Extended Abstract Data from hundreds of passive treatment systems demonstrate successful improvement of abandoned mine water quality by decreasing ecotoxic metals concentrations, and increasing alkalinity concentrations and pH. However, certain biologically-based process units may produce excessive concentrations of atypical, non-mine drainage related constituents. These predominately anaerobic units (*e.g.* vertical flow bioreactors) are designed to promote reductive microbial mechanisms. Therefore, even if functioning properly from a mine water quality improvement perspective, effluent waters may initially contain excessive amounts of non-target contaminants, *e.g.* biochemical oxygen demand (BOD), sulfide, and nutrients, have low dissolved oxygen concentrations and oxidation-reduction potential, and cause nuisance odor problems. Compounding a general lack of understanding of these issues, these non-mine drainage water quality constituents are not typically included in most monitoring schemes and system performance evaluations.

At the study site, artesian discharges of net-alkaline, ferruginous waters from abandoned underground lead-zinc mines cause considerable surface water degradation. A passive treatment system (≈ 2 ha total surface area), completed in 2008, was designed to receive 1000 L/min of mine water flowing from abandoned boreholes (pH 5.95±0.06, total alkalinity 393±18 mg/L $CaCO_3$, total acidity 364±19 mg/L $CaCO_3$, Fe 192±10 mg/L, Zn 11±0.7 mg/L, Cd 17±4 µg/L, Pb 60±13 µg/L and As 64±6 µg/L). The system includes an initial oxidation pond followed by parallel treatment trains of aerobic wetlands, vertical flow bioreactors, re-aeration ponds, and horizontal-flow limestone beds, and a final polishing wetland/pond.

Mean final effluent waters had pH >7, were n*et al.*kaline and contained < 1 mg/L total Fe and 0.2 mg/L total Zn, and had concentrations of Cd, Pb and As below detectable limits. However, the vertical flow bioreactors seasonally produced concentrations of nitrogen, phosphorus and sulfide that exceeded applicable water quality or aquatic toxicity criteria, and which presented nuisance odor problems. BOD values were not elevated. Summer nitrogen and phosphorus concentrations in the final effluent were 1.01±0.26 mg/L and 0.59±0.14 mg/L, respectively, well above U.S. Environmental Protection Agency (EPA) nutrient criteria. Summer sulfide concentrations in the final effluent were greater than the U.S. EPA freshwater criterion continuous concentration of 2 µg/L, with vertical flow bioreactors effluent concentrations of 15.8±9.22 mg/L.

The re-aeration ponds include renewable energy-driven (solar- and wind-powered) re-aeration devices, which demonstrated seasonally effective enhancement of re-oxygenation and mixing of the water column downstream of anaerobic process units. More robust monitoring schemes, including constituents beyond the typical mine water parameter suite, may be appropriate when anaerobic process units are included in passive treatment system designs.

Keywords vertical flow bioreactors, re-aeration, nuisance constituents, eutrophication, toxicity