PASSIVE TREATMENT USING COAL COMBUSTION PRODUCTS: AN INNOVATIVE VERTICAL FLOW CONSTRUCTED WETLAND FIELD STUDY[1]

by

R.W. Nairn, M.N. Mercer and J.W. Everett[2]

Abstract: Designs of constructed wetlands for acid mine drainage (AMD) treatment have evolved substantially during the past decade. Current research focuses on the study of vertical-flow treatment systems containing labile organic substrates. Also known as successive alkalinity producing systems (SAPS), these systems emphasize contact of acidic waters with the substrate, thus maximizing biological alkalinity generation, via bacterial sulfate reduction, and abiotic alkalinity generation, via carbonate dissolution processes. In this study, a coal combustion product (CCP) was utilized to generate supplementary alkalinity in addition to that provided by traditional substrate materials of spent mushroom substrate (SMS) and high $CaCO_3$ content limestone. Although limestone is commonly utilized for abiotic alkalinity generation in AMD treatment wetlands, CCPs are not. The preliminary effectiveness of this innovative vertical flow passive treatment system was evaluated during the initial year of operation. The system consists of four 185 m^2 in-series cells and is comprised of alternating vertical flow anaerobic compost wetlands (VFs) and surface flow aerobic settling ponds (APs). The substrate in the VFs consists of SMS and high $CaCO_3$ content limestone gravel, supplemented with hydrated fly ash (HFA) in a 2:1:0.1 ratio by volume. Initial laboratory column studies identified HFA, one of several coal combustion product tested, as an effective alkalinity generating material for passive treatment systems. A portion (approximately 17 L/minute) of an AMD discharge (2500 L/minute mean discharge rate, 460 mg/L acidity as $CaCO_3$ eq., pH 3.5, 205 mg/L total Fe, 10 mg/L Al^{+3}, 12 mg/L Mn^{+2} and 1800 mg/L SO_4^{-2}) from an abandoned underground mine in southeastern Oklahoma was directed to the pilot-scale treatment system. Field data and water samples for subsequent analyses were collected at the discharge, at the inflow to each cell, and at several locations in the receiving waters. Initial data indicate a pH increase to 7.6, and generation of approximately 350 mg/L alkalinity as $CaCO_3$ eq in the first VF. Final discharge waters exiting the second AP consistently exceed water quality requirements for active mine sites (alkalinity >acidity; iron <2.0 mg/L; 6<pH<9), with exception of manganese. Net alkalinity values are approximately 170 mg/L at the outflow of the second AP. Mean removal rates are approximately 21 g acidity m^{-2} day^{-1} and 7 g Fe m^{-2} day^{-1}, respectively. The wetlands are successfully retaining iron, aluminum and manganese and are increasing pH, alkalinity, dissolved oxygen (from <1.0 to >13 mg/L, due to biological productivity), and calcium (from 31 to 385 mg/L, presumably due to limestone and hydrated fly ash dissolution). No hydraulic conductivity problems have been encountered in the initial year of operation. CCPs may offer an attractive alternative, or supplementary, alkalinity generating source for AMD treatment wetlands.

Additional key words: acidity removal, alkalinity generation, fly ash, constructed wetlands

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[2] Robert W. Nairn is Assistant Professor of Environmental Science and Matthew N. Mercer is Graduate Research Assistant, The University of Oklahoma, Norman, OK 73019-0631 and Jess. W. Everett is Associate Professor at Rowan College, Glassboro, NJ 08028.