A Deterministic Model for Predicting Alkalinity from Limestone for Design of AMD Passive Treatment Systems[1]

Jonathan M. Dietz [2] and Brian A. Dempsey

ABSTRACT. Mine drainage (MD) water quality varies from highly acidic pH (<3) to circumneutral pH (6-7). Passive treatment systems for MD usually require additional alkalinity, and this is often accomplished by dissolution of calcite limestone. Proper design of alkalinity-producing components of treatment systems for MD requires accurate models that account for effects of temperature, ionic strength, pH, and initial calcium and carbonate concentrations. Design parameters are typically based on past performance from constructed systems for different MD characteristics or from on-site cubitainor or pilot-scale studies. In this investigation a deterministic model was developed for prediction of the maximum alkalinity (at infinite reaction time) and the rate of alkalinity generation, for various MD types. The model consists of two components. The first component is a maximum alkalinity estimation model (MAEM) that accounts for alkalinity, calcium, pH, ionic strength, and temperature to predict a maximum alkalinity. The MAEM model predicted maximum alkalinities to within ten percent of measured alkalinities from long term cubitainor studies and ALD systems. The second component of the model is an alkalinity kinetic model (AKM) that was developed using data obtained from several time-varying alkalinity cubitainor studies, conducted on various water types. The analysis of this time-varying data indicated alkalinity generation was a second-order rate reaction, which is consistent with the stoichiometry of the calcite reaction. A second-order reaction rate coefficient (k_{alk}) of 3.1×10^{-10} $M^{-1}s^{-1}$ at 12°C was determined from the data. A study is underway to determine the activation energy (E_a) for the reaction rate coefficient. The combined MAEM-AKM provides estimates of maximum alkalinity and alkalinity for various MD chemistries and for any limestone contact time. The MAEM-AKM model is an important tool to assist managers and engineers in developing projects and designs to abate mine drainage discharges.

[1]Paper was presented at the 2002 National Meeting of the American Society of Mining and Reclamation, Lexington KY, June 9-13, 2002. Published by ASMR, 3134 Montavesta Rd., Lexington, KY 40502.

[2]Jon Dietz, Ph.D. Candidate Environmental Engineering Program, Department of Civil Engineering, Pennsylvania State University and principal at Dietz *et al* Consulting, LLC, 672 Devonshire Drive, State College, PA 16803

Brian A. Dempsey, Professor of Environmental Engineering, Department of Civil Engineering, Pennsylvania State University, 205 Sackett Building, University Park, PA 16801