Topic WQ-2

White Paper Topic: Contaminant Loading - Prediction of Contaminant Concentrations from Coal Mines

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Problem Definition:

The two basic methods of mine drainage prediction are static tests and kinetic tests. The static tests are reviewed in Chapter 4 of the ADTI prediction book by Skousen et al. (2000) and the kinetic tests are reviewed in Chapter 5 of that book by Geidel et al. (2000). Additional mine drainage prediction techniques, including geologic influences, groundwater chemistry from previously mined areas, and natural groundwater quality from adjacent unmined areas are described in Chapters 8 through 10 by Brady and others (1998) in the PA DEP mine drainage prediction book. The most widely used static test method is acid-base accounting (i.e. Total Sulfur vs. Neutralization Potential), and although kinetic tests are not used as routinely as static tests, by the coal mining industry and regulatory agencies, the most commonly used kinetic tests are leaching columns and humidity cells.

In acid-base accounting procedures, the total sulfur test is usually reliable and widely used by the mining industry and others, with the LECO sulfur analyzer being the most commonly used equipment/method. The NP test was originally developed by M.L. Jackson (1958) to measure the neutralizing equivalence of agricultural limestones for plant growth purposes, was adapted to mine land reclamation by R. M. Smith and others of West VA University, and then was incorporated into mine drainage prediction procedures by Smith, Sobek and others in a series of EPA publications including Sobek et al. (1978). That NP method has been used by most labs for the past 25 years, but a siderite interference problem with the method was recognized by Meek (1981) and others, and a modified NP method was developed by Skousen et al. (1997) that solves the siderite interference problem in addition to providing other improvements in the test method. Unfortunately, this modified NP procedure has not been universally adopted by the regulatory agencies, the commercial labs and the mining industry----thus, data inconsistency problems still abound. The total sulfur test and the NP test are surrogate measures or predictors of the actual acidity or alkalinity concentrations that will be produced by weathering the rock samples in the lab or the mine environment. However, these acidbase accounting procedures have been proven to be useful for many stratigraphic sequences - although they do not produce an actual contaminant concentration that can be compared to contaminant concentrations in field water samples in pit waters, post-mining discharges or groundwater monitoring wells. Therefore, these mine drainage prediction methods are sufficient for predicting whether acidity will exceed alkalinity in many rock types and mine permit scenarios, but they have limitations in the “grey zone” described by Geidel et al. (2000) and they do not provide accurate measurements or interpretations of the concentrations of iron, manganese, aluminum or any trace elements of interest (e.g. selenium). Kinetic tests are needed to obtain prediction test results on rock samples from proposed mining sites, which are expressed in concentrations of acidity, alkalinity, sulfates, iron or other parameters of interest. A key issue is whether the kinetic test results can be equated to the concentrations of these mine drainage parameters that will occur in the actual min edrainage produced during mining or post-mining. Several studies (e.g., Bradham and Caruccio, 1990 & 1995, and Caruccio and Geidel, 1986) have compared various kinetic test methods to attempt to identify the best predictors. There have also been several studies to compare overburden analysis predictions to the actual mine drainage quality (e.g., diPretoto and Rauch, 1988, and Brady et al., 1994), but these studies are on acidbase accounting results, because there are so few kinetic test results in permit files of state agencies. This lack of kinetic test data in permit files is largely attributable to the lack of widely accepted standard kinetic test methods for many years. Some excellent kinetic test results are in the scientific literature and in site-specific research studies, but the state and federal regulatory agencies, the mining industry and its consultants previously have not been able to embrace a particular kinetic test method or group of methods as the accepted standard. The CMS Prediction Work Group has been taking steps to remedy this problem in the past few years, and at least one ADTI standard kinetic test method is close to completion of the methods development process.

Members of the ADTI-CMS Prediction Workgroup have written two book chapters in anticipation of developing standard kinetic test methods. The chapter by Hornberger and Brady (1998) in the PA prediction book presented a review of the kinetic test literature of the past 50 years and a summary of the physical, chemical and biological factors involved in kinetic tests. The chapter by Geidel et al. (2000) in the ADTI prediction book provided recommendations and guidelines for standardization of kinetic test methods. A team of ADTI Prediction Workgroup members have been working with OSM and EPA to produce two standard kinetic test methods: the ADTI-WP1 Humidity Cell method and the ADTI-WP2 Leaching Column method. The results of the first year of method development and testing in 2 labs was reported in Hornberger et al. (2003) and the second year of testing of the revised standard method in 3 labs was reported in Hornberger et al. (2004) and Brady et al. (2004). The paper by Brady et al. (2004) contains a thorough evaluation of the carbonate and sulfate data directed toward predicting the alkalinity and acidity concentrations, and whether alkalinity will exceed acidity in long term weathering of the rock samples.

The original structure of the ADTI Prediction Workgroup had three subcommittees: static tests, kinetic tests and field validation (including sampling considerations). While the ADTI prediction book (2000) is a very useful document, much more work could be done in the area of field validation of static and kinetic test methods------to develop relationships between prediction methods and the actual contaminant concentrations in the field. The functions of the Prediction Workgroup described herein are now principally contained in the Water Quality Group under the new organizational structure of the ADTI-CMS.

COURSE OF ACTION:

1. The Water Quality Workgroup should discuss and consider some further limited testing of the modified NP method, based upon concerns and questions raised by commercial labs. These concerns deal with the effect of filtration vs. the peroxide digestion step, and the use of the insoluble residue test as a precursor to the NP titration, for purposes of removing subjectivity in the fizz rating.
2. The Water Quality Workgroup should evaluate the results of the limited additional NP testing, and make a recommendation to the IMCC to communicate to all member state regulatory programs to adopt the modified NP method, and inform the mining industry, consultants and commercial labs to use the modified method.
3. The ADTI-CMS and IMCC should make state regulatory programs, the mining industry, consultants and laboratories aware of the ADTI standard reference material (SBC-1 Brush Creek Shale) that was developed by USGS (Steve Wilson of the MMS). This sample was developed for use in quality control work on acid-base accounting samples, but has also been used in the development of the standard kinetic test methods. This is the only standard reference material of the ADTI-CMS and consideration should be given to the need for additional standard reference materials.
4. A full interlaboratory study is needed to complete the method development work on the ADTI-WP2 Leaching Column Method and to have EPA publish the draft method in the Federal Register. This study must include at least 7 or more labs to meet ASTM Standard D 2777 on method development. A proposal to do this interlaboratory validation study was approved by the OSM Technology Transfer Team, and the project is jointly funded by OSM and EPA for FY 2005/2006 in cooperation with CSC/Dyncorp (contractor for EPA) and PA DEP. The 8 labs participating in the study include two university labs (Penn

State University-Material Research Institute and West Virginia University-National Mine Land Reclamation Center), a federal government lab (USGS), an industry lab (Consol Energy R&D) and four commercial labs (Mahaffey Laboratories, Geochemical Testing, Sturm Environmental Services and Benchmark Analytics). The 14 week weathering study of four shale samples from PA, WV and IN, and a relatively inert sandstone (e.g. blank) commences in January 2006 and will be completed in April 2006. CSC/Dyncorp will conduct the statistical analysis of method performance criteria pursuant to ASTM and EPA protocols for method development.

5. Evaluate the interpretive approaches of Brady et al. (2004), Geidel, Caruccio et al. (2000) and others in defining relationships between prediction methods and contaminant concentrations (and pollution loads) on an individual weathering event basis and on a cumulative (i.e. short term/long term) basis.
6. Compile data from field validation studies in various states, and determine the data gaps and if any communalities exist in the field validation data as related to prediction methods.
7. Conceptualize the task of developing relationships between prediction methods and mine drainage parameter concentrations on several levels of interest:
   a. acidity and alkalinity concentrations; major element concentrations (iron, manganese, aluminum, etc.); and trace element concentrations (cadmium, chromium, selenium, etc);
   b. results of static tests, kinetic tests (lab) and field weathering tests; and
   c. differences in relationships among different rock types (distinctly acidic/distinctly alkaline/grey zone).
8. Revisit the interpretive approaches (#5 above) when the additional data becomes available (from #4 above and other new data sets). Complete the data evaluation and interpretations and conclusions.
9. Publish the results as an addendum to the 2000 ADTI prediction book.

COST OF PROJECT:

Step #2 above can be completed for and estimated cost between $5K and $20K Step #4 above can be completed for estimated costs between $150K and $225K (The present funding for the inter-laboratory validation study is a total of about $170K from several funding sources, and there will be some additional costs between publication of the draft method and the final EPA method.)

The costs for the other steps of the course of action are essentially ADTI member time in evaluating data and writing a report.

TIME REQUIRED:

Step #2 above can be completed in a few months. Step #4 will be completed by July 2006, but the process of publishing the draft method, responding to comments and publishing the final method could take another year or two. The remaining tasks could be completed within 3 years from the present date.

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