USING LABORATORY LEACHING METHODS TO EVALUATE CCBs

David J. Hassett
University of North Dakota
Energy & Environmental Research Center
Grand Forks, North Dakota

Abstract

The Energy & Environmental Research Center (EERC) has performed numerous research projects that have included the use of laboratory leaching tests to evaluate the environmental performance of Coal Combustion By-Products (CCBs), and that experience has lead the EERC to develop an understanding of the key considerations that must be made when evaluating CCBs. These key considerations include the need for use of an appropriate leaching solution, the need to include multiple long-term leaching tests for reactive CCBs (and other reactive materials), and the need to use a test that provides information that has relevance to the potential disposition of the CCB.

Keywords: Leaching, SGLP, CCBs

Introduction

Even following the U.S. EPA determination to place CCBs under RCRA Subtitle D for solid wastes (1), CCB generators are frequently asked to provide information on the environmental performance of CCBs that are being either disposed or utilized. Frequently, the leaching protocol to be used is mandated or recommended by the requesting party, but considering that the leaching results may have multiple uses and that the U.S. EPA has indicated that any leaching test that can be shown to be appropriate may be used, it is meritorious to consider options for leaching tests. In considering which test or tests to use, the number and types of available tests may be somewhat overwhelming, if not confusing. It is important to understand what information the leaching test is being performed to provide and that the results of the leaching tests must be scientifically valid and defensible. If the goal is simply to categorize a material under an existing regulatory policy, rule, or law, and there is a mandated test for that categorization, it may be reasonable to apply that test as dictated. Categorization of a CCB usually provides an indication of a regulatory status for that material within a State and subsequently an indication of how the CCB can be managed, especially how it may be utilized. Applying an authorized test, however, should not preclude the generation of valid data potentially through the use of an alternate test. This may require a dialogue with regulatory agencies or users of the data. The process of selecting a leaching test and subsequent dialogue with stakeholders should take into account several criteria that will facilitate the generation of valid information that can be used to make good CCB management decisions potentially beyond those included in a preconceived categorization process.

These criteria are:

1. Reactivity or other properties of the material being leached that may influence the leaching profile;
2. The setting where the material is to be placed and the water that will most likely contact that material in that setting; and
3. The leaching time required to allow adequate time for hydration reactions to occur in reactive materials, such as high calcium coal fly ash.

The Value of Laboratory Leaching Tests

Understanding the information that can be ascertained from laboratory leaching is important. A laboratory leaching method can only be used to determine a few important elements of leaching, but these are extremely important, and if properly utilized, can provide information on which responsible CCB management decisions can be made.

These are:

1. The mass of easily mobilized trace elements can be determined using a leaching test with a short equilibration time.
2. A comparison of bulk concentrations of elements with their leachate concentrations provides a means of estimating how various elements will be mobilized with respect to time.
3. The evolution of leachate concentrations can be determined with multi-equilibration time long-term leaching,

Laboratory leaching cannot provide an estimation of the concentration of elements in leachates under natural conditions with any high degree of accuracy. This, however, is not as limiting as it might seem for several reasons. First, the concentration of chemical constituents under natural leaching conditions will be a product of several factors that are not easily duplicated in laboratory leaching. These are rate of flow through the leached material and rate of flow around the mass of leached material, assuming that there is a flow of water through and around the individual site. In properly engineered disposal or utilization sites, this should not be the case. Assuming, however, that there is flow in and around the material, simple modeling using known flow rates can be used to determine likely field concentrations under natural groundwater flow conditions. Since flow in many natural settings is extremely slow (10^{-5}-10^{-7} cm/sec), it is impractical to use laboratory column leaching tests to determine potential for environmental impact of reactive alkaline CCBs. Column leaching could be used and supported both legally and scientifically if the flow rate through the column were slow enough to allow for the formation of secondary hydrated phases, but since this takes months or longer, a flow rate that low through a 50–100 cm column is too slow to be practical. The problem with faster flow rates is that individual components required for secondary hydrated phase formation are washed away before reactions can occur. Ettringite formation requires the presence of alkalinity, soluble calcium, aluminum, and a source of suitable oxyanion such as sulfate. Since these must be leached from the ash, and since the leaching and dissolution rates are different for each of the elements, a relatively high water flow would be expected to wash away critical parameters necessary for ettringite formation.

Advantages and Disadvantages of Common Laboratory Leaching Tests When Used With CCBs

There are advantages and disadvantages to most leaching tests currently being used for CCB environmental performance testing. The advantages alone do not make any one test the best test. It is important to also understand the way in which the CCB is to be introduced into the environment and, of course, what information is being sought by performing the leaching test. Similarly, the disadvantages of individual tests may not disqualify that test from being appropriate for a particular use. It is important to understand the advantages and disadvantages. The EERC has assembled a list of leaching tests commonly used for CCBs and the advantages and disadvantages of each as the EERC sees it (Table 1).

The EERC preferentially uses and recommends the SGLP with the long-term leaching (LTL) option where appropriate because it has the advantage of meeting the criteria for a scientifically valid and legally defensible method. When distilled deionized water is used for the SGLP, it is equivalent to ASTM D3987. Results from SGLP are easily compared to those from TCLP, SGLP, SPLP because all tests use very similar protocols. When incorporating the LTL option with reactive materials, the interpretation of the test results include a comparison of the short-term data set and results of two LTL tests of 30 and 60 (or 90) days. This comparison provides an indication of changes to the leaching profile of a reactive material over time. Since it is unrealistic to assume that a laboratory leaching test can provide an indication of field leachate quality, the EERC believes it is important to assess laboratory leachate data carefully. The EERC agrees that a specific set of limits for laboratory leachate concentrations may be useful in assessing the appropriateness of a material for placement in the environment as long as those limits have been developed with an understanding of the environmental setting. The use of laboratory leaching data in computer models used to predict impacts to groundwater may provide better predictions of actual field concentrations of constituents mobilized from CCBs, but computer models frequently do not incorporate adequate information on the environmental criteria that impact field leachate quality.

Summary

The debate of which method or methods are appropriate for characterizing environmental performance of CCBs continues with a productive dialogue underway. It is important that this dialogue includes stakeholders from the CCB industry and experts in the fields of both CCBs and environmental performance testing. It is unrealistic to think that one leaching test will emerge as the single test appropriate for use with CCBs, but it is expected that the dialogue will facilitate a better understanding of what leaching data can tell producers, users, regulatory agencies, and other interested parties.

David J. Hassett is a Senior Research Advisor at the Energy & Environmental Research Center (EERC) of the University of North Dakota. He also serves as the Fuels Analyst for the State of North Dakota. He has authored or coauthored over 200 publications and holds a patent entitled "Enhanced Ettringite Formation for the Treatment of Hazardous Liquid Wastes, U.S. Patent 5,547,588. He is presently involved in several research projects. His principal areas of interest and expertise include the application of analytical chemistry to address environmental issues associated with trace element occurrence, transport, and fate; coal combustion byproduct management; groundwater quality; and air quality. The most recent research focus has been on trace element transformations during coal conversion processes and interaction between groundwater and coal conversion solids as related to the leachability of trace elements. Additional areas of expertise include hydration reactions of coal conversion solid residues as well as organic synthesis, radiochemistry, x-ray spectrometry, analytical chemistry, and vegetable oil diesel fuels. In 1985, he presented his research on vegetable oil diesel fuels as a member of a People to People Biomass Utilization Delegation to the People's Republic of China and, in 1998, was an invited keynote speaker at the 15th Conference on Clay Mineralogy and Petrology held in Brno in the Czech Republic. He has laboratory experience with infrared spectroscopy, gas chromatography, neutron activation analysis, atomic spectroscopy (atomic absorption and inductively coupled argon plasma), thin-layer chromatography, ultraviolet and fluorescence analysis, x-ray fluorescence spectroscopy, nuclear magnetic resonance spectroscopy, ion chromatography, laser spectroscopy, and capillary electrophoresis. He holds a B.S. in Chemistry and Mathematics from Winona State University in Minnesota.

Table 1. Leaching tests commonly used for CCBs, advantages and disadvantages.

Leaching Test	Advantages	Disadvantages
TCLP EPA 1311 Toxicity Characteristic Leaching Procedure	1) Easy to perform and replicates well between laboratories.	1) Leaching solution limits use to materials only when disposed in sanitary landfills. 2) Lacks long term component for reactive ash.
SPLP EPA 1312 Synthetic Precipitation Leaching Procedure	1) Easy to perform and replicates well between laboratories. 2) Uses a leachate appropriate to specific environmental situations.	3) Lacks long term component option for reactive ash. 4) Developed to evaluate impact of contaminated soils on groundwater.
ASTM D3987	1) Easy to perform and replicates well between laboratories.	1) Lacks long term component option for reactive ash.
MWLP Mine Water Leaching Procedure	1) Well designed for evaluating CCBs to be placed in acidic mine settings.	1) Designed for specific site conditions, so results are not broadly applicable.
SBLP Serial Batch Leaching Protocol	1) Contains an option to evaluate alkaline CCBs.	1) Not yet standardized. 2) Lacks long term component option for reactive ash. 3) Multiple liquid-to-solid ratios and leaching solutions make the test time consuming and results difficult to interpret.
SGLP/LTL Synthetic Groundwater Leaching Procedure/ Long-Term Leaching	1) Provides optional long term component for reactive ashes. 2) Allows for leaching solution to be selected site specific conditions. 3) Easy to perform.	1) Not yet standardized. 2) Long term component may require up to 90 days.