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Use of the Leaching Environmental Assessment Framework (LEAF) for future fly ash management decisions

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Abstract

The Leaching Environmental Assessment Framework (LEAF) is a collection of leaching tests, data management tools, and leaching assessment approaches developed to identify detailed characteristic leaching behaviors of a wide range of solid materials. Cohesive integration of these components provides materials-specific "source term" release information for support of decisions involving materials management. In the U.S. and in other industrialized countries, the increasing use of secondary materials such as fly ash, foundry sands, and other industrial by-products is important economically and environmentally. Primary materials must be excavated or mined, processed, and transported. In the U.S., 130 million tons of coal combustion residues (CCRs) were generated in 2011with 44% used in a range of applications such as mine reclamation, cementitious materials, highway construction, building products, structural fill, waste solidification, and even toothpaste. The applications can have very different environmental conditions and knowledge of the leaching behavior of pollutants found in industrial by-products will vary based on the environmental conditions that the materials encounter over time.

Historically, estimating the leaching of pollutants has been based on single-point extraction tests, that represent one set of possible leaching conditions (e.g., one pH level), which may not reflect the actual conditions of leaching in the field. These new methods, consider the effect of three parameters known to strongly affect constituent mobility and transport: (1) pH of the water contacting the waste, (2) amount of water contacting the waste over time, and (3) physical form of the waste. By reflecting the plausible range of environmental conditions that significantly affect constituent leaching, the LEAF methods represent a significant improvement over the past practice of relying on the results of single point leaching tests. Further, the LEAF leaching tests respond to concerns with leach testing that have been raised by EPA's Science Advisory Board (SAB) on several occasions, going back as far as 1991.

The LEAF test methods, which began as research tools, have been developed into standardized tests for routine use in commercial, academic, and national laboratories.

Evaluation of the LEAF methods, which involved testing of the same wastes at multiple laboratories to validate the precision and reproducibility of the four methods, was completed in 2012 and reports have been published. Data on waste leaching in the field and in the LEAF tests have been compiled and evaluated, finding good agreement between the data documenting the accuracy of the methods for use in future policy decisions. The methods have been posted as "new methods" on the EPA Office of Solid Waste and Emergency Response's (OSWER's) analytical methods guidance (SW-846) website.

The initial use of these methods was to evaluate the fate of pollutants in air pollution control (APC) residues from state-of-the art air pollution control technology at coal-fired power plants. The LEAF methods have provided an integrated approach to determine the fate of pollutants such as arsenic, boron, chromium, mercury, and selenium that are captured through APC technology at coal fired power plants, based on how the APC residues are managed. Coupled with the changes occurring to CCRs as a result of APC requirements at coal-fired power plants which preferentially partition mercury and other constituents to fly ash and other APC residues, it became increasingly important to understand whether cross media transfers were occurring so that improvement in one environmental medium was not being traded off for another. CCRs are considered a high volume waste in the U.S. Since 2001, utilization of CCRs has grown from 32% to 44% as of 2011 (33 to 57 million tonnes). In some instances, CCRs appear to work better than the materials they replace, such as longer life of some concrete building products. However, better characterization of potential leaching behavior – particularly in light of changes to CCRs in response to APC changes – is needed to ensure protection of human health and the environment.

This research supports EPA's strategic goals to improve air quality, protect America's waters, clean up communities, and advance sustainable development. The LEAF methods have been crucial to Agency efforts to understand the amount of constituents leaching from APC residues disposed on land and taking into account the range of disposal conditions and the changing composition of coal combustion residues with respect to coal types and APC adoption. This research is regarded as a model for EPA's integrated, trans-disciplinary research because it uses a holistic approach to inform management of APC residues to ensure that captured pollutants are not transferred back into the environment based on management method chosen.

The U. S. EPA evaluated a range of leaching tests, ultimately selecting the LEAF test methods because of their flexibility to address a range of materials, environmental conditions, and release scenarios. In studying CCRs, leaching variability was found to range by several orders of magnitude and depend on the conditions that the CCRs encounter in the environment. To validate and expand the use of the LEAF tests, partnerships were formed with 20 laboratories in the U.S. and Europe. Recognizing the need for data management tools, the research team developed software (LeachXS-Lite) built using existing software (saving major expense). Users are provided free access to LeachXS-Lite for data management, viewing, and comparison to similar materials. In addition, Excel spreadsheets were generated for each method for data entry, analysis, and uploading to LeachXS-Lite.

In parallel to the U.S. EPA effort, Europe has developed comparable methods. Europe recently decided they will use the validation data generated from the recent U.S. research instead of repeating the work that was done. As a result, Europe and the U.S. will be able to readily share data in the future that is comparable across a range of materials and management scenarios. Use of secondary materials – while ensuring protection of human health and the environment – can help lead towards more sustainable solutions that conserve energy and natural resources.

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