Update on EPA's Development of New Leaching Tests – Leaching Evaluation Assessment Framework (LEAF)

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Outline

- Background
- Leaching Evaluation Assessment Framework (LEAF) Test Methods
- LEAF How-to Guide
- Examples of use of LEAF
- Next Steps
- LEAF bibliography

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Leaching Evaluation Assessment Framework (LEAF)

- LEAF test methods are designed to characterize leaching behavior for a wide range of materials and associated use and disposal scenarios.

- LEAF How-To Guide provides technical guidance on:
  - Four LEAF test methods (Methods 1313, 1314, 1315, 1316)
  - Data management tools (LeachXS, LeachXSLite)
  - Quality assurance/quality control
  - Integrated leaching assessment approaches
  - Leaching source term development

- LEAF data was used to support the CCR Rule Risk Assessment

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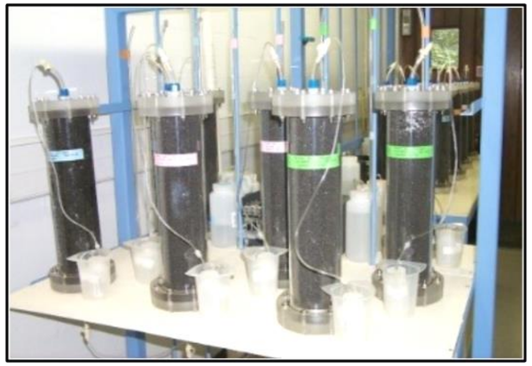
LEAF Test Methods

- Posted to SW-846 Validated Methods in August 2013
- Equilibrium-based leaching tests
  - Batch tests carried out on size reduced material
  - Aim to measure contaminant release related to specific chemical conditions (pH, LS ratio)
  - Method 1313 – pH dependence & titration curve
  - Method 1316 – LS dependence

- Dynamic leaching tests
  - May be either equilibrium limited or mass transfer rate limited
  - Aim to determine contaminant release rates by accounting for both chemical and physical properties of the material
  - Method 1314 – upflow column, percolation leaching, local equilibrium (LS ratio)
  - Method 1315 – carried out either on monolithic material or compacted granular material



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Simulation Tests vs. Characterization(LEAF) Tests

Existing Tests

- Single-Point "Simulation-based" Leaching Approach
  - Designed to provide representative leachate under specified conditions
  - Simple implementation (e.g., single-batch methods and interpretation, acceptance criteria)
  - Limitations
    - Representativeness of testing (may or may not reflect actual disposal or use conditions)
    - Results may not be reliable if extended to scenarios that differ from simulated conditions

LEAF Tests

- Multi-Point "Characterization-based" Leaching Approach
  - Evaluate intrinsic leaching parameters under broad range of conditions
  - Designed to identify the impact of key factors on leaching potential (pH, liquid/solid ratio, particle size)
  - More complex; sometimes requiring multiple leaching tests
  - Results can be applied to "what if" analysis of disposal or use scenarios
  - Allows a common basis for comparison across materials and field conditions

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LEAF Data Management Tools

- Data templates and LeachXS Lite software facilitate data management, evaluation and reporting
- Data templates provided as excel spreadsheets for each method
  - Perform basic, required calculations (e.g., moisture content)
  - Record laboratory data
  - Archive analytical data with laboratory information
  - Form the upload file to materials database
- Software for LEAF data management, visualization and processing
  - Compare leaching test data
    - Between materials for a single constituent (e.g., as in two different CCRs)
    - Between constituents in a single material (e.g., Ba and SO_4 in cement)
    - To default or user-defined values indicating QA limits or health-based threshold values
    - Identify maximum and minimum leaching for each COPC and conditions under which they occur
  - Export leaching data to Excel spreadsheets

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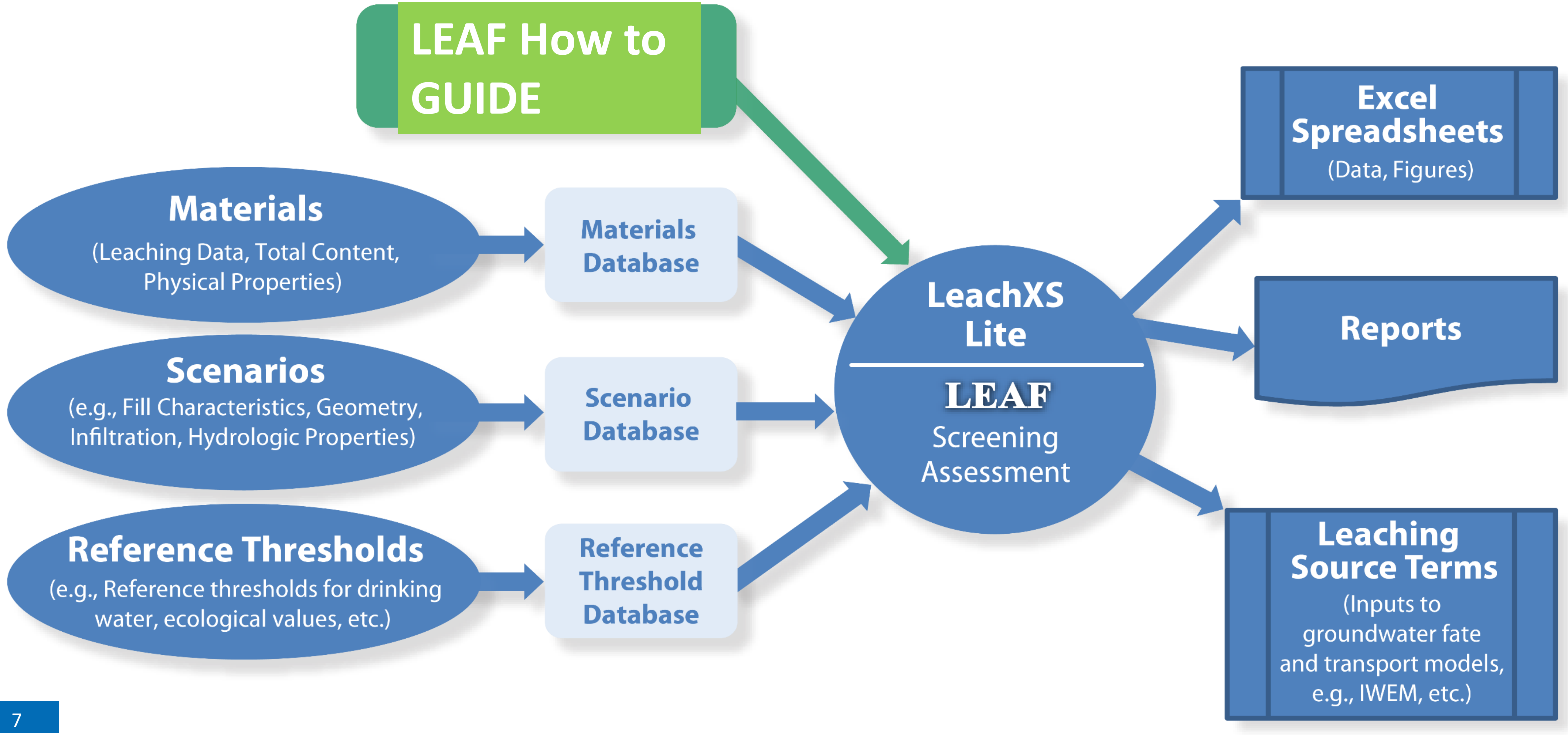
LeachXS Lite Inputs, Databases and Outputs



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LEAF How-To Guide: Purpose

- Overall, LEAF can be complex and detailed; tiered evaluation may include:
  - Screening assessments
  - Scenario assessments
  - Effects not assessed by tests
- The How-To Guide explains
  - How to apply LEAF and how leaching results are used
  - The value of using LEAF in an assessment
  - How the test results are used in the assessment approach
  - Describe data management and analysis tools
- Guidance designed to help potential users apply LEAF approach to project needs to support environmental decision-making.

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LEAF How-To Guide: Audiences

Goal: Describe the LEAF tests and evaluation framework:

How to determine which test(s) to use and how to conduct testing

Explain the potential applications and value of LEAF testing.

- Decision makers for waste management, beneficial use of secondary materials, and site remediation
- Risk assessors
- State environmental agency officials
- Waste generators
- Analytical laboratories
- Technical consultants and other interested stakeholders

LEAF How-To Guide: Topics Covered

- General leaching overview
- How to proceed through the LEAF approach
- How to apply LEAF and special considerations to assess for selected management scenarios (disposal or reuse)
- Case study examples that use the LEAF approach such as reuse of coal fly ash as fill material
- How to use leaching test results to estimate releases and inform beneficial use decisions and other voluntary uses of LEAF (e.g., treatment effectiveness of hazardous waste or contaminated sites)

Outline for LEAF How-To Guide

- Section1: An Introduction to LEAF and this Guide
  - Purpose of the guide
  - Intended audience
  - What is LEAF
- Section 2: Understanding the Leaching Process
  - What is leaching
  - What is a source term
  - How does leaching occur
- Section 3: An Overview of LEAF
  - Test methods
  - Laboratory best practices
  - Data management tools
- Section 4: Developing Leaching Evaluations using LEAF
  - Potential applications
  - Developing an integrated assessment
  - Important environmental factors
- Section 5: Case Study of Using LEAF for Screening Assessments
  - Evaluating Coal Combustion Fly Ash for Use as Fill Material

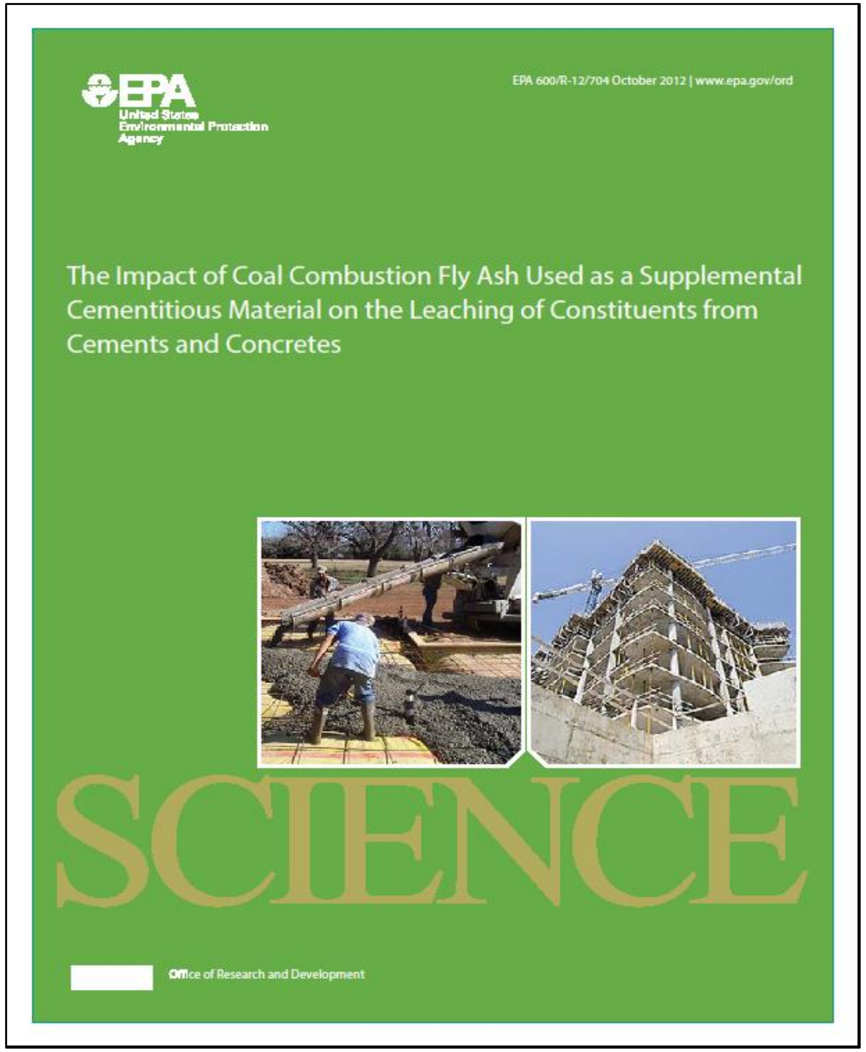
EPA's Beneficial Use Definition

- Virtually all industrial sectors generate by-products that are typically discarded but may be used to replace natural resources and conserve energy
- EPA has defined beneficial use as the incorporation of an industrial material into a commercial product that:

1) provides functional benefit
2) meets relevant design specifications and performance standards for the proposed use
3) replaces virgin, raw materials in a product already on the market and
4) is implemented in a environmentally acceptable manner

Example of use of LEAF in evaluating how leaching of cementitious materials compare between use of portland cement or coal fly ash

- 2012 U.S. EPA Report compared LEAF data from:
  - 31 cement mortar and concrete samples containing coal fly ash
  - 21 cement and mortar samples that did not contain coal fly ash
- Results indicate that large portion of coal fly ashes currently being produced can be used in cement and concrete formulations without causing potential adverse environmental impacts



Example use of LEAF – EPRI funded work to evaluate fly ash use in concrete

- 4 fly ash sources, representative of range of COPC leaching
  - Samples of fly ash currently being used in commercial mixes
  - 2 from bituminous coals, 2 from sub-bituminous coals
- 0 (control), 20 and 45% fly ash replacement loadings for Portland cement
- Commercial concrete mix designs and micro-concretes (45% CFA only)
- Sample curing of 28 days, 3, 6 and 12 months
- Leaching (Methods 1313, 1314 and 1315) and physical testing
- Also effects of carbonation and decalcification on COPC leaching

***Project supported by Electric Power Research Institute (EPRI), K. Ladwig, project officer**

Garrabrants, A.C., Kosson, D.S., DeLapp, R., van der Sloot, H.A., 2014. Effect of coal combustion fly ash use in concrete on the mass transport release of constituents of potential concern. *Chemosphere* 103, 131-139.

Kosson, D.S., Garrabrants, A.C., DeLapp, R., van der Sloot, H.A., 2014. pH-dependent leaching of constituents of potential concern from concrete materials containing coal combustion fly ash. *Chemosphere* 103, 140-147.

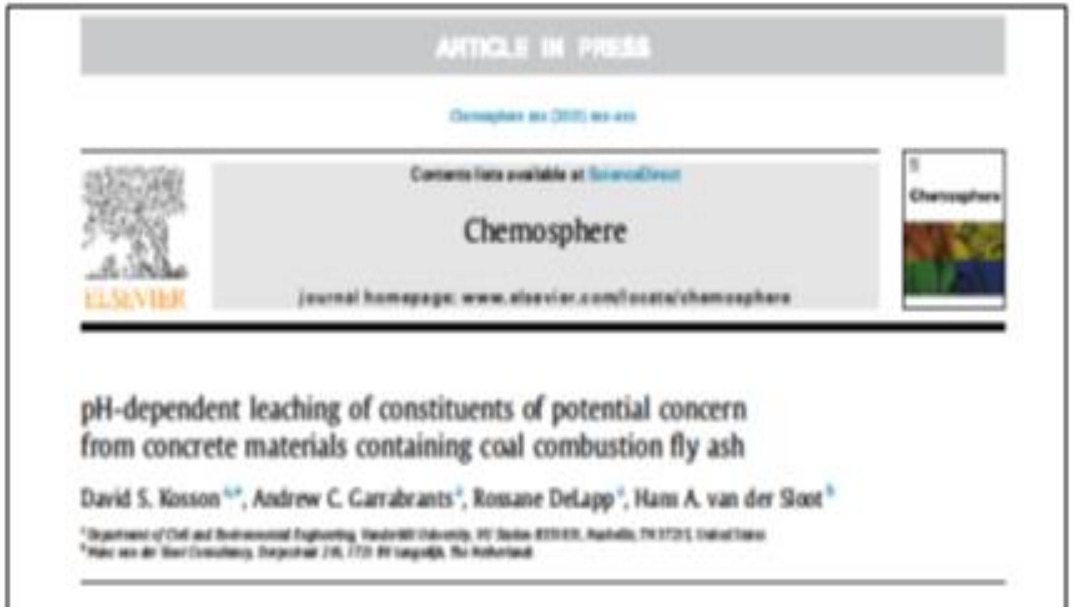
US EPA Reports – Methodology and Evaluation of using Coal Fly Ash and FGD Gypsum

- Methodology for Evaluating Encapsulated Beneficial Uses of Coal Combustion Residuals (September 2013)
  - https://www.epa.gov/sites/production/files/2016-10/documents/methodology_for_evaluating_beneficial_use_of_secondary_materials_4-14-16.pdf
- Coal Combustion Residual Beneficial Use Evaluation: Fly Ash Concrete and FDG Gypsum Wallboard (U.S. EPA, EPA530-R-14-001, February 2014)

  (EPRI funded the study that resulted in data that was used to evaluate fly ash use as substitute for Portland Cement)

  - https://www.epa.gov/sites/production/files/2014-12/documents/ccr_bu_eval.pdf

Verification of Findings on example coal fly ashes being marketed for this application



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Chemosphere

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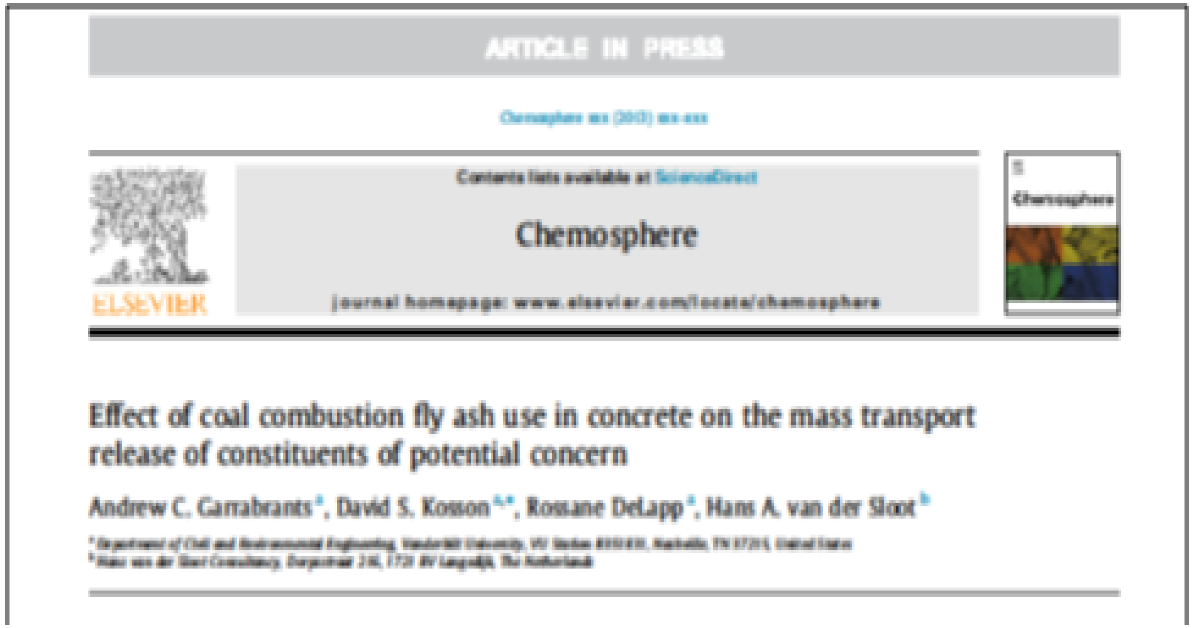
ELSEVIER

pH-dependent leaching of constituents of potential concern from concrete materials containing coal combustion fly ash

David S. Kosson[a,*], Andrew C. Garrabrants[a], Rossane DeLapp[a], Hans A. van der Sloot[b]



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Andrew C. Garrabrants[a], David S. Kosson[a,*], Rossane DeLapp[a], Hans A. van der Sloot[b]

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Next Steps

- Receiving comments from public review of LEAF How to Guide (90 day review period closing 1/31/18)
- Continue to refine, add data, and improve user interface for LeachXS-Lite and Method Excel spreadsheets (using input from various users both in the U.S. and internationally)
- Would like to add different source term applications to automate source term development in LeachXS-Lite for input to fate and transport models. Potential for collaboration with this work?
- Parallel effort ongoing to developing leaching tests for organic constituents of potential concern – using LEAF principles of accounting for the effects of most important factors affecting leaching – interest in reviewing the methods for organic constituents?

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