WEACAU-III: International Workshop on
Environmental Aspects of Coal Ash Utilization
Tel Aviv, Israel
December 11th – 12th 2012

Geochemical speciation of coal combustion residues and field observations in relation to beneficial use in construction applications

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Abstract

Development of a robust approach for leaching assessment requires the ability to use laboratory leaching test results to estimate field leaching under a range of beneficial use and disposal scenarios. Confidence in understanding the impacts of different uses (e.g., in concrete, road base, embankments, etc.), chemical conditions (i.e., pH, redox) and hydraulic conditions can be achieved through a combination of evaluating the range of expected material properties and field conditions, laboratory-to-field comparisons and coupled geochemical speciation and mass transfer models. Extensive data sets have been compiled for coal combustion residues (CCRs), including fly ash and scrubber residues, as well as cement mortars and concretes produced using coal fly ash (Kosson et al, 2009, van der Sloot et al, 2012). In addition, field leaching behavior of coal fly ash under different use and disposal scenarios has been evaluated. This presentation will focus on the use of geochemical speciation and coupled mass transfer models in the assessment approach using examples of coal fly ash under different use and disposal scenarios.

The characterization of leaching from CCRs and products containing CCRs using the recently validated standardized characterization leaching tests that determine pH dependent leaching (e.g., CEN TS 14429, EPA Method 1313; Garrabrants et al, 2012a), leaching under percolation conditions (e.g., CEN TS 14405, EPA Method 1314; Garrabrants et al, 2012b), and leaching under diffusive mass transport conditions (e.g., CEN TS 15683, EPA Method 1315; Garrabrants et al, 2012b) has provided the data required to conduct and verify geochemical speciation modeling to understand release controlling processes (van der Sloot et al, 2010; van der Sloot et al, 2012). The resulting speciation and coupled mass transport models provide a basis to assess long term release under changing environmental exposure conditions by considering the changes in liquid-solid partitioning of elements under different chemical conditions and water contact scenarios. Using proper thermodynamic stability data for minerals and other solubility controlling parameters such as binding to Fe-oxide, Al-oxide, clay, dissolved organic carbon and particulate organic matter, a chemical speciation fingerprint (CSF) can be developed for specific CCRs. , The modeling framework ORCHESTRA (Objects Representing CHEmical Speciation and TRAnsport models; Meeussen, 2003) embedded in LeachXS as the data management system is used for geochemical speciation and chemical reaction/transport modeling.

The pH dependent leaching behavior in combination with the calculated chemical speciation of constituents in the solid phase and in solution allows judgment of the solubility controlling phases. Aqueous speciation can be related to the bioavailability

of constituents through their distribution between the free and DOC-bound fraction of an element in solution. This approach provides a means of assessing changes in material behavior for judgment of treatment options and beneficial use applications. Based on the individual CSFs, the behavior of material mixtures and products prepared with coal combustion residues can be evaluated prior to testing a potential product (van der Sloot et al, 2010).

When the release behavior as obtained by the characterization leaching tests is combined with the results from geochemical speciation and with field observation after a longer period of exposure under field conditions (> 5 years), changes in the geochemical properties due to re-mineralization can be assessed. This allows conclusions on possible long term changes in CCR materials or CCR containing products.

Proper waste management, satisfying environmental and health related criteria, requires a fair amount of information on a wide range of substances. The integrated approach highlighted here with testing, geochemical modeling and field verification forms a powerful basis for identifying environmentally acceptable beneficial use scenarios.

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