

Quantifying the Release of Bioactive Trace Elements from Coal Combustion Products to Natural Waters

Candace Wall, Bettina Sohst, Greg Cutter, Peter Sedwick
Ocean, Earth and Atmospheric Sciences, Old Dominion University

Research supported by the Tennessee Valley Authority through Oak Ridge Associated Universities



Coal Combustion Products



- although the majority of coal combustion products (CCPs) are buried in landfills, significant amounts enter natural waters via power plant emissions, losses during handling, and unintended direct releases
- relative to other geological materials, coal can contain relatively high concentrations of a number of bioactive trace elements, some of which are further solubilized during the combustion process
- hence there is a need to understand the possible environmental impacts of the release of bioactive trace elements from CCPs that are deposited into natural fresh waters such as rivers, lakes and reservoirs

Mobilization of Bioactive Trace Elements from Coal Combustion Products

- bioactive or toxic trace elements that may be released from CCPs include: N, P, V, Cr, Mn, Fe, Co, Cu, Zn, Ar, Se, Cd, Sb, Pb, Hg, Tl & U
- numerous studies have focused on the mobilization of trace elements from landfill CCPs by groundwater and rainwater, whereas relatively little research has examined the release of these species into rivers and lakes
- due to high solution-to-particle ratios in such situations, batch-leaching methods are unlikely to yield results that can be reliably extrapolated to CCPs in rivers and lakes, given likely precipitation of secondary phases
- hence new techniques are required to quantify the release of bioactive trace elements from CCPs into natural waters such as rivers and lakes



Goals of Our Current Research

- use flow through leaching experiments to quantify the release of bioactive trace elements from CCPs that are deposited into natural fresh waters
- determine whether CCPs release elements with a characteristic 'fingerprint' that might serve to indicate CCP pollution in natural fresh waters

Methods: CCP Leaching Procedure

- rapid, flow-through leaching method simulates interaction of CCPs with relatively large volume of fresh water
- ~0.1 g of CCPs are leached 3 x with 250 mL of natural fresh water
- method avoids potential problems with solution saturation/precipitation inherent in batch-leach methods
- leaching and leachate solutions are analyzed by inductively-coupled plasma mass spectrometry (ICP-MS)



flow-through leaching (using aerosol sample)



Thermo Element2 ICP mass spectrometer

Methods: CCP Digestion

- method based on EPA 3052 for digestion of siliceous and organically based matrices
- ~0.1 gram of CCPs added to HCl/HNO₃/HF mixture in teflon digestion vessel
- samples processed in CEM MARS microwave digestion system and then analyzed using ICP-MS
- rigorous 'trace-metal clean' protocols used in all methods



CEM Closed Vessel Microwave Digestion System

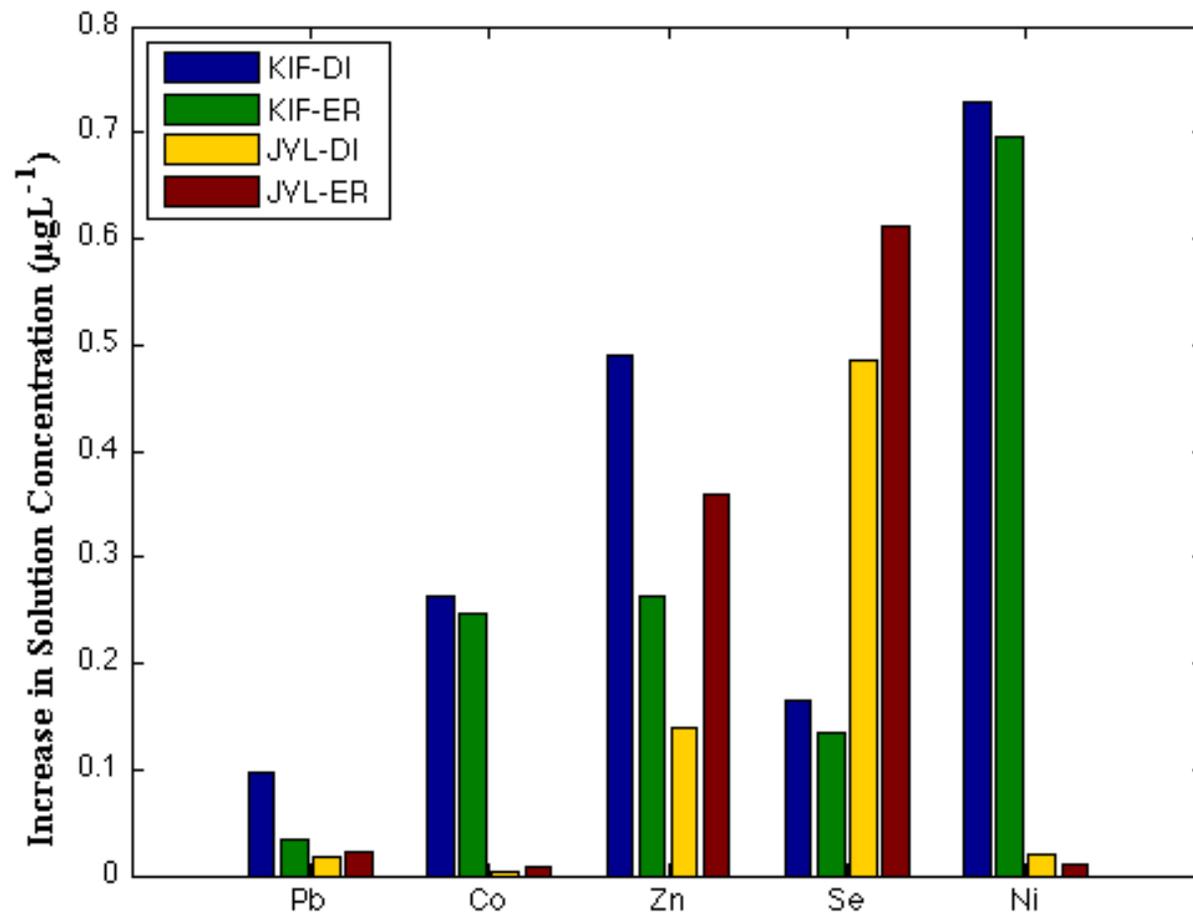
Initial Progress

- development of Quality Assurance Project Plan (ongoing)
- testing and refinement of microwave digestion procedure for coal fly ash standard reference materials (ongoing)
- leaching experiments performed using 2 different CCPs: fresh fly ash from Johnsonville (JVL) & Kingston (KIF) plants
- leaching experiments performed using 3 different leaching solutions: filtered Emory River water (upstream of KIF site); filtered Lake Drummond water (organic-rich, low-pH); and ultrapure deionized water (as 'control' leaching solution)

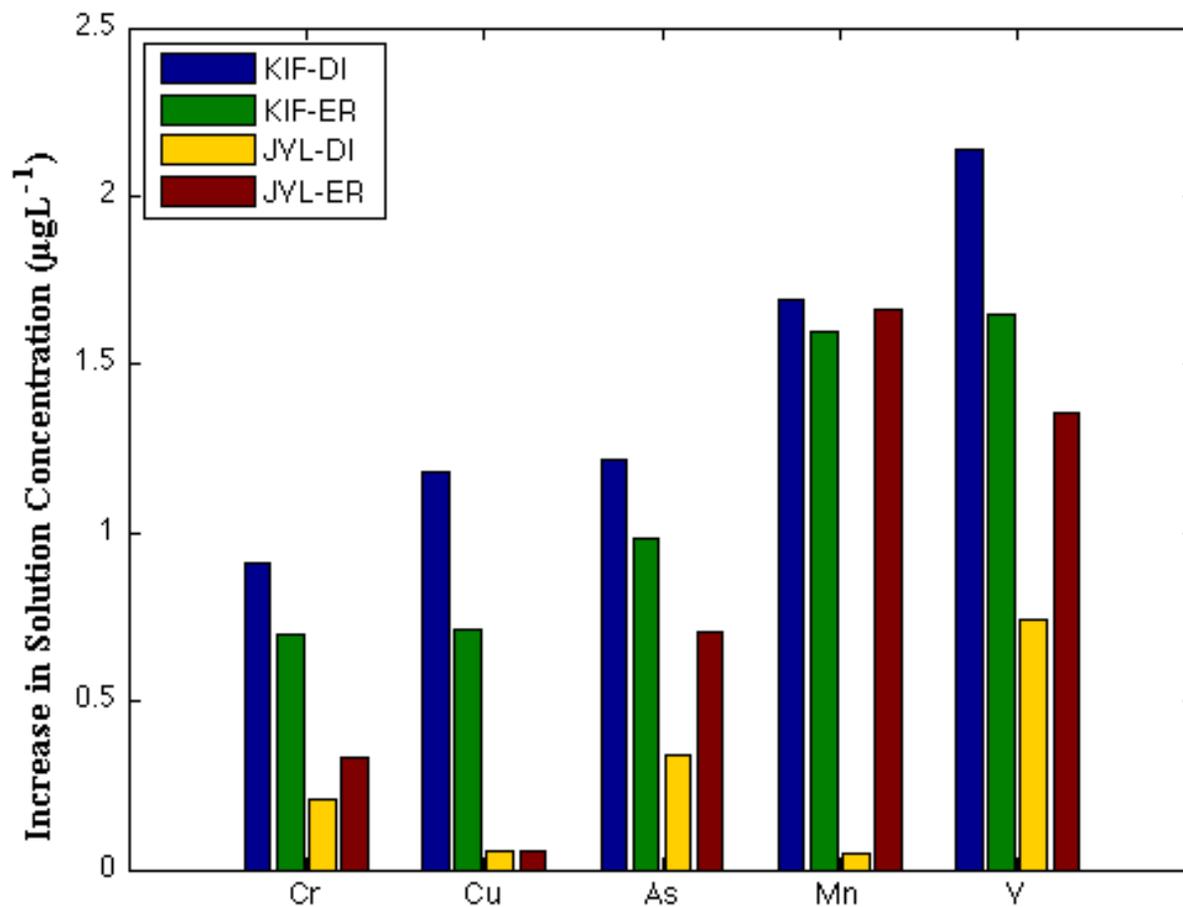
Preliminary Data:
Recovery from Digestion of SRM 1633a (Coal Fly Ash)

Element	Average % Recovery
Fe	84 ± 9
Sb	97 ± 5
Ar	101 ± 3
Cd	155 ± 14
Cr	93 ± 4
Cu	117 ± 6
Mn	81 ± 16
Ni	109 ± 5
Pb	98 ± 4
Se	105 ± 7
Tl	100 ± 8
U	81 ± 3
V	96 ± 3
Zn	117 ± 8
Co	97 ± 6

Preliminary Data: trace elements released from fly ash into Emory river water



Preliminary Data: trace elements released from fly ash into Emory river water



Preliminary Findings

- preliminary data reveals significant net release of several bioactive trace elements (V, Cr, Zn, As, Se, Cd, Tl, Pb) into leach solutions (Emory River water and deionized water)
- net release of trace elements into solution appears to depend on types of CCPs and on type of fresh water

Further Work

- additional leaching experiments will be performed using further different types of CCPs and fresh waters
- after optimization of digestion procedure with SRMs, the various CCP samples will be digested and analyzed
- data from analysis of digest and leach solutions will be used to calculate fractional solubility of trace elements in CCPs with respect to various types of fresh water

Acknowledgments

- TVA and ORAU for research funding and support
- TVA personnel for providing ash samples and for assistance with river water collection
- Fred Wurster and Great Dismal Swamp NWR for assistance with sampling Lake Drummond