Mobilization and Bioaccumulation of Trace Elements from Coal Fly Ash

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The United States produces approximately 65 Mt of coal fly ash annually. The leaching of potentially toxic trace elements from fly ash may threaten public health and the environment. A spill from the TVA Kingston coal-fired plant left an estimated 330,000 cubic meters (750,000 metric tons) of residual ash, containing 5 to 1000 metric tons of specific trace elements, in the surrounding riverine and riparian sediment. This research characterized the dissolution and biouptake of major and minor (trace) elements from class F coal fly ash from the Kingston plant. The ash consisted of 60% glass/amorphous matrix and 40% minerals based on X-ray diffraction. X-ray absorption spectroscopy (XAS) showed both reduced (Se^{+4} and Cr^{+3}) and oxidized (As^{+5},U^{+6}) forms of trace elements.

Effluent from abiotic, continuously flow-stirred tank reactors (CFSTR) were analyzed for trace elements during 8 days of flow at each of three controlled pH levels (5,7, and 10), both under oxic and anoxic conditions. Results showed that the dissolved concentrations of trace elements varies with both pH and redox state of the influent solution, with some elements of concern leaching preferentially under oxic conditions (Se and Cr) or anoxic conditions (As and U). XAS data showed that Se from the reacted fly ash transformed from Se^{+4} to Se^0/SeS_2 under anoxic conditions with increasing transformation with decreasing pH. Oxidation states of other trace elements were unchanged.

Effluent from the pH=7 oxic and anoxic CFSTR experiments were placed in contact with periphyton for three days under batch conditions to measure trace-element uptake. Under oxic conditions, trace metal uptake was greater than the control periphyton while anoxic conditions showed concentrations at or less than the control, indicating mobilization of trace elements initially in the periphyton. This research demonstrates that the mobilization and biouptake of trace elements from coal fly ash is strongly dependent on pH and redox conditions and may occur under environmentally relevant conditions.