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Spatially Resolved X-Ray Microanalysis of Nickel in *Salix nigra* L. Tree Cores From An Aged Contaminated Site

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Beamline(s): X26A

Introduction: The Steed-Pond-Tim's Branch depositional system is located on the Department of Energy's Savannah River Site, near Aiken, South Carolina. Steed Pond served as a settling basin for effluents originating from a target fabrication facility between 1955-1985. Effluents that entered Steed Pond (SP) contained depleted uranium (^{238}U), and other metals (Ni, Cr, Cu, Zn and Pb). An estimated 44,000 kg of U was deposited in SP. In 1984 and again in 1993 the wooden spillway damming SP breached, releasing contaminated sediments into the lower reaches of TB and depositing them in riparian zones. During storm events, transport of contaminated sediments from SP rises to 1500-2800% of base flow, with the most chemically labile forms of U associated with remobilized sediments (Batson, 1996). This study used a retrospective biomonitoring technique (dendroanalysis) combined with spatially resolved x-ray microanalysis to show the effects of spillway breach on the metal concentration within annual rings of *Salix nigra* at TB.

Methods and Materials: Tree cores were collected from mature Salix nigra L. (black willow) at TB and a control site located upstream from contaminant releases. Total metal concentration of adjacent soil was determined by ICP-MS. Cores were collected with a Teflon-coated increment corer (20cm x 0.5 cm). Cores were dried (60 °C, 48h), cut into 2 cm sections, maintaining orientation with respect to bark and heartwood and sliced longitudinally with a dissection blade to >1mm thick. Sections were mounted on metal-free KAPTON tape and analyzed by synchrotron-based X ray fluorescence (XRF) microscopy. Using an incident beam size of 300 μm, 90 second dwell time per pixel and a step size of 500 μm, cores were analyzed initially by 1 dimensional XRF line scans through the central longitudinal axis, and then by 2D mapping of selected metal-rich regions. Ion-chamber normalized XRF counts were converted to mg kg^{-1} by calibrating with SRM 1575 (Pine needles). Replicate tree cores were aged via standard image analysis techniques.

Results: U and Ni concentrations in TB soils were 805 and 265 mg kg^{-1} respectively. Elevated concentrations of Ni were detected within annual rings of TB tree cores, corresponding to the approximate dates of the spillway breaches; namely 1984, 1987 and 1993 (Figure 1). Background Ni concentration in plant tissues is 0.2-5 mg kg^{-1} (Adriano, 2001), and after the initial breach, baseline Ni in TB tree cores was approximately 100 mg kg^{-1}. Line scans show similar peaks for Cr, Cu, Zn and to a lesser extent Pb occurring at the same time. 2D maps (Figure 2) of metal content within as well as between rings show that metals are not uniformly distributed throughout annual rings.

Conclusions: U is not bioavailable to plant tissues, and there were elevated concentrations of Ni, Cr, Cu, Zn and Pb within tree core samples. Ni concentration peaks coincide with approximate dates of spillway breaches. Peaks were also observed in Cr, Cu, Zn and to a lesser extent Pb at the same times, suggesting that bioavailable metals are strongly co-associated. Distribution of metals within tree rings is not homogeneous in this case, perhaps reflecting the patchy deposition of metals in the soil. Analysis of tree cores using this technique successfully identified contamination events, although this work signifies a need for greater replication and the use of 2D mapping to show potential heterogeneity.

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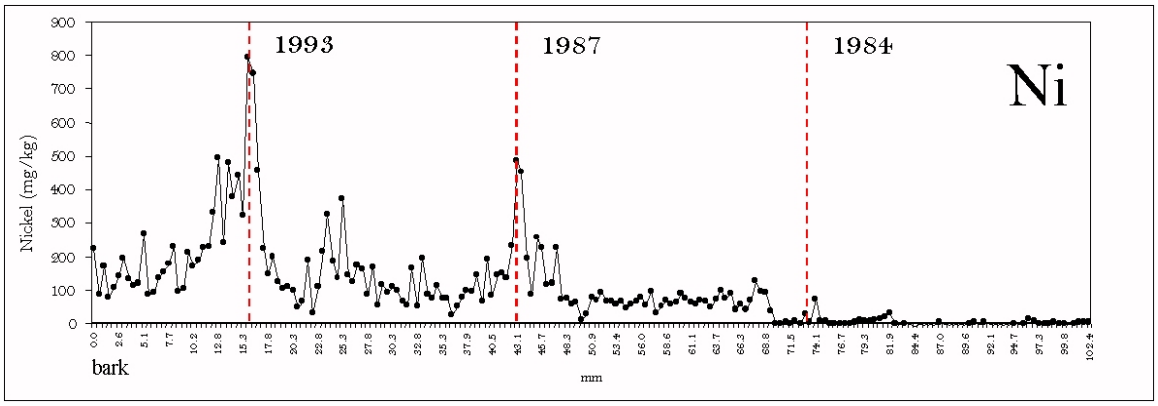

Figure 1. Concentration of Ni within annual rings of *Salix nigra* growing downstream from a former settling basin.

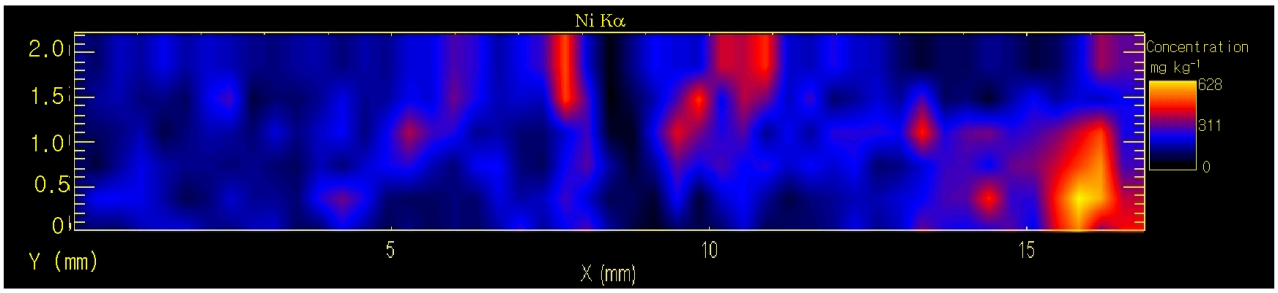

Figure 2. Two-dimensional map of the distribution of Ni within a section of *Salix nigra* woody tissue.