Watershed-Scale Hydrobiogeochemical Properties that Cause Contaminant Hot Spots

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Project Abstract: Argonne's Wetland Hydrobiogeochemistry SFA is a multi-scale study of the hydrobiogeochemical processes governing water quality at a uranium (U) contaminated wetland located on the Savannah River Site, Aiken, SC. The objective of this study was to determine hydrological, soil, and topographical properties that influence U concentration distribution along an 8 km reach. The general approach was to create U concentration maps, collect and characterize soil cores for U properties, and then use flow models to test various hypotheses to explain the presence of multi-hectare-sized hot spots of U. Using walk-over gamma mapping techniques, the area previously surveyed was expanded another 30% to ~40 hectares. Based on 400,000 gamma spectra and 10 soil cores, it was determined that 94% of the originally released 43,500 kg U remain in the wetland, mostly in five hot spots. The furthest hot spot (9 ha) was 8 km downstream of the source term and accounted for 11% of the detected U. Uranium soil concentrations in this hot spot were as high as 2000 mg/kg and were near perfectly correlated to organic matter and iron concentrations. A hydrological and contaminant transport model was calibrated and validated against measured data. It showed that the hot spots are located only in marshy wetlands, as opposed to uplands, and in areas where stream energy is or was extremely low, such as former ponds. Modeling results suggest that stream particles are responsible for much of the U transport in this system. Surprisingly, few U-rich particles could be found in sediments recovered from the hot spots using autoradiography followed by SEM/EDX techniques. The few hot particles that were found contained 12 to 16 wt% U. Together these results demonstrate that wetlands can be highly effective at immobilizing U for more than 50 years. Furthermore, contaminant reconcentration occurs only in areas where the hydrological conditions as well as sediment biogeochemical conditions are conducive. Results from this meter-to-hectare scale study are being combined with on-going laboratory gram-scale and spectroscopic molecular-scale studies to inform a model to predict water quality in wetlands.