Real-time, on-site and quantitative detection of bioavailable radionuclides and heavy metals in contaminated water at DOE sites

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Quantitative, real-time detection of radionuclides and heavy metal ions on-site remains a significant challenge while monitoring environmental resources such as groundwater and surface water. At the Integrated Field Research Center in Rifle, subsurface water contaminated with soluble and labile U(VI) is being converted to insoluble U(IV) by microbial action to fix the uranium and therefore an on-site sensor that can specifically quantify U(VI) in groundwater will provide a tool for monitoring uranium speciation and remediation progress.

Lu and coworkers have reported a DNAzyme based fluorescent uranium sensor with a detection limit of 11 ppt and high selectivity. It is specific for U(VI) as DNAzyme's are specific to a particular oxidation state of a metal. ANDalyze Inc. commercialized several DNAzyme based heavy metal sensors including sensors for uranium, lead, copper, zinc, cadmium and mercury using a combination of dry form sensor cartridge and a hand-held fluorimeter. The tests can be done in 2 minutes. The focus of our poster is the commercialized uranium sensor with a detection range of 2 - 60 ppb and a typical uranium recovery of 75-125% for field testing.

Previously, we collaborated with Ken Williams and Phil Long at Rifle and with Tonia Melhorn and Kenneth Lowe at ORNL to test our uranium sensor with samples from Rifle and ORNL sites. Twelve ORNL samples with ppm level uranium were analyzed after dilution and the results compared well to ICP (80-120% recovery). The Rifle samples had lower recovery of ~ 50%. We then optimized the protocol to test samples at Rifle which require a simple acidification to ~pH 5 prior to analysis by adding few drops of dilute acid. With the optimized protocol, we traveled to the Rifle site to perform field analysis of samples. Eight samples were analyzed using two each from plots A, B, C and D and the results compared to ICP. The samples had a uranium recovery of ~ 70-110% (compared to ICP results) which works well for quick, on-site field analysis. Since most samples showed a lower result than ICP, we are testing various uranium complexes that maybe found in the Rifle subsurface to test their effect on the sensor's ability to quantify U(VI) and therefore improving sensor performance.

To add capability of remote monitoring, we are currently in the process of developing a continuous monitor which will allow for unattended operations up to 30-days, while testing samples at a specified frequency.