Constructing a solution to a mercurial problem

An artificial wetland that should be fully constructed by the end of this month may provide key clues about how man-made marshes can eliminate mercury from surface water, according to scientists at the U.S. Department of Energy's (DOE) Savannah River Site in South Carolina. The project is one of many innovative remediation technologies being investigated on the wooded, 310-square-mile site where DOE once produced radioactive uranium, plutonium, and tritium for nuclear bombs.

Pilot tests of a smaller version of the wetland being constructed on an 8-acre plot outside the Savannah River facility's main testing laboratory show that it is able to drastically reduce the mercury content of water passing through it. The pilot-scale wetland consistently cut mercury levels from between 100 and 700 ng/L to less than 45 ng/L, said John Gladden, manager of the environmental analysis section for the DOE site's Environmental Science and Technology group.

Most importantly, the pilot wetland produced less than 1 ng/L, on average, of methylmercury, the form of metal that bioaccumulates in aquatic life, Gladden said. Methylmercury can affect the nervous system of animals that ingest it, including humans, and EPA is spending more than $6 million to research the fate and transport of mercury in aquatic systems throughout North America, said Arnold Kuzmack, senior science advisor for EPA's Office of Water.

The fact that very little methylmercury is being generated by the pilot wetland is impressive because marshes, swamps, and bogs are inherently good places to produce this problematic form of mercury, said Cindy Gilmour, associate curator of the Estuarine Research Center operated in southern Maryland by the Academy of Natural Sciences. And the Savannah River project's method of limiting methylmercury production by controlling the wetland's sulfur concentrations is new, she added.

Designed by wetland specialist John Rodgers of Clemson University, Savannah River's man-made swamp's ability to sequester mercury is a fortuitous side effect of its original purpose to remove copper, lead, and zinc from water runoff. Relying mainly on gravity, the wetland will process 1 million gallons of water a day; an adjacent dam can hold up to 25 million gallons of water a day in stormy weather. The wetland is expected to cost \$4.5–\$4.8 million—less than half the price of the alternatives considered—when it is completed, and its water will ultimately flow into the Savannah River.


Savannah River Site

When it is filled with water, the lush growth of bullrushes in the artificial wetland being constructed on this site will discourage waterfowl from landing on it.

The artificial marsh funnels incoming water through two of eight identical treatment cells. Initially, the metals in the water bind onto organic matter in the *Scarpus californicus* bullrushes planted in the wetland. Eventually, this matter decomposes and is attacked by bacteria that remove the oxygen from it, sending the metals into the oxygen-free sediments at the bottom of the treatment cells, which contain sulfur in the form of gypsum. In the chemically reducing environment that predominates there, the metals form insoluble sulfur compounds, Gladden said.

Maintaining the right sulfur level to catalyze the formation of those insoluble compounds is tricky, stressed Gilmour, who advised the Savannah River scientists. "We don't exactly know what the magic sulfate concentration for this wetland is," she explained. "It's very complex chemistry, and it probably varies from ecosystem to ecosystem."

At this point, whether the mercury levels coming off the wetland will satisfy EPA regulators is uncertain. If the actual wetland functions identically to the pilot wetland, which Gilmour predicts may not be the case, the mercury levels will be above the 13 ng/L level mandated by the National Pollution Discharge Elimination System permit for the creek it feeds. It is unclear whether the site could obtain a variance.

Further complicating the issue are EPA's eventual plans to cut the allowable mercury levels in aquatic systems to between 1 and 5 ng/L, Kuzmack said. Both he and Gilmour agreed that any methylmercury—even as little as 1 ng/L—is too much. And Bill Payne, an environmental scientist for the Savannah River Site, acknowledged that some of the mercury coming off the creek fed by the wetland, probably in the form of Hg(II), could be transformed to methylmercury by the time it reached the Savannah River.

In the meantime, the DOE scientists are focusing heavily on how to minimize the mercury coming off the wetland, Gladden said.