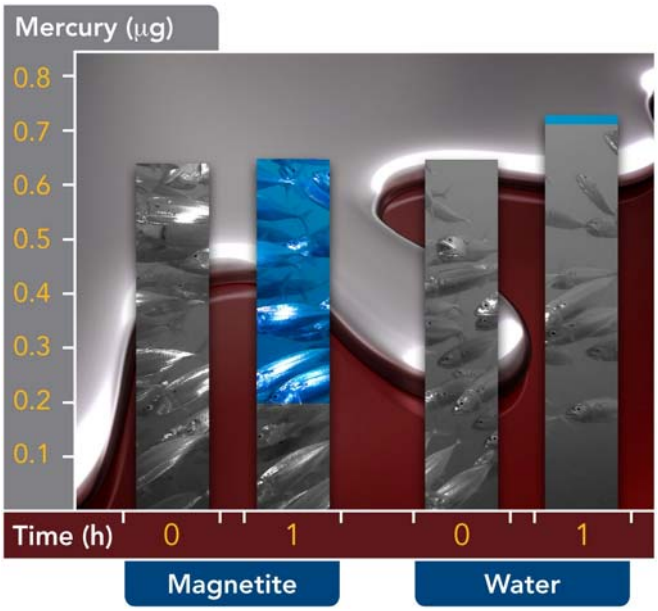
Iron Mineral Limits Mercury Toxicity

Used in separating isotopes at U.S. nuclear weapons production sites, tons of mercury were released to the soil and groundwater. In anoxic or low-oxygen sediments, bacteria transform this silvery element when in the form of Hg(II) into a neurotoxin by adding a methyl group (-CH_3). The resulting methylmercury is a potent neurotoxic substance that accumulates in fish, which are harvested for food.

In a recent study, highlighted in *Science*, researchers from Rutgers University, the Department of Energy's EMSL, and Pacific Northwest National Laboratory showed that a simple iron mineral transforms Hg(II) to gaseous Hg(0). The mineral known as magnetite or Fe(II)/Fe(III) mixed valence iron oxide turns Hg(II) into Hg(0) in just minutes. Subsurface bacteria cannot add a methyl group to the gaseous mercury, so it does not become the neurotoxic methylmercury.



Magnetite reduces the amount of mercury in solution. This transformation makes the mercury unavailable for conversion by bacteria to a toxin.

The researchers conducted kinetic experiments at Rutgers University. These experiments showed that the Hg(II) gains electrons within minutes of entering an environment with magnetite. At EMSL, the scientists did Mössbauer spectroscopic analysis of reacted magnetite samples. The analysis revealed decreased Fe(II) in the magnetite. This decrease corresponds to the oxidation of Fe(II) to Fe(III) coupled to the reduction of Hg(II) to Hg(0). Finally, they used X-ray photoelectron spectroscopy to detect Hg(II) on magnetite surfaces. This analysis implied that adsorption is involved in the electron transfer process.

The results of these analysis suggest that the reaction of Hg(II) with the Fe(II)-containing oxide is a favorable pathway. This research helps scientists understand and eventually control the creation of toxic methyl mercury.

Scientific impact: This research suggests that mineral-associated processes, such as adsorption and phase transformation, may provide stiff competition in mediating mercury's fate and mobility. This research is one example of EMSL's work to move molecular understanding to the broader continuum.

Social impact: Mercury was spilled and released as waste to the soil and groundwater at nuclear weapons production sites. In sediments with low levels of oxygen, bacteria can add a methyl group to the mercury, creating the neurotoxic substance methylmercury. To understand the formation of methylmercury, scientists need accurate information from this and related studies on the geochemistry of mercury.

For more information, contact EMSL Communications Manager Mary Ann Showalter (509-371-6017).

Reference: Wiatrowski HA, S Das, R Kukkadapu, ES Ilton, T Barkay, and N Yee. 2009. "Reduction of Hg(II) to Hg(0) by Magnetite." *Environmental Science & Technology* 42(14):5307-5313. DOI: 10.1021/es9003608

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