

NATURAL ORGANIC MATTER FAILS TO MAKE MORE MERCURY CLING TO BACTERIA

Mercury is the most ubiquitous, persistent, and damaging heavy metal pollutant in the environment. As researchers look for methods to aid in clean-up, one possibility might be to recruit bacterial species in adsorbing the toxin. A group of physicists and earth scientists evaluated the influence of natural organic matter on mercury adsorption onto three kinds of bacteria. Through analyses conducted at the APS, they determined that while the presence of organic matter, in the form of fulvic acid (FA), does decrease mercury adsorption to biomass, three-part bacteria–Hg–FA complexes do not form under the tested conditions. While FA can bind to cell walls, and it can bind to mercury, it does not bind to both. Many laboratory studies that investigate mercury's binding properties use a simple “metal plus ligand” approach. Its real workings in the environment are, of course, far more complex. In a river system, mercury might encounter any number of minerals, organic compounds, and other metals. In an experiment conducted at the MR-CAT 10-ID-B and XSD 9-BM-B,C beamlines at the APS, the researchers from the University of Notre Dame, the Illinois Institute of Technology, and Princeton University evaluated the influence of organic compounds (using FA as a proxy) on mercury's behavior as a way to start looking at the complexities of more natural systems.

Fulvic acid is a natural, widely persistent organic compound found in the environment. The research team used intact non-metabolizing bacteria—likely their more natural state in the environment—to study mercury adsorption as a function of pH and FA concentrations. Previous lab studies have shown mercury binds very strongly to sulfur groups and it is known that FA has sulfur binding sites. The team was hoping to find an ability to make ternary complexes, and that the presence of both of the ligands would enhance mercury adsorption. But that was not what they found.

Their analysis revealed that as organic matter concentrations increased, so did the concentration of aqueous mercury, implying that FA seems to compete with mercury for bacterial cell wall adsorption sites. Mercury can also

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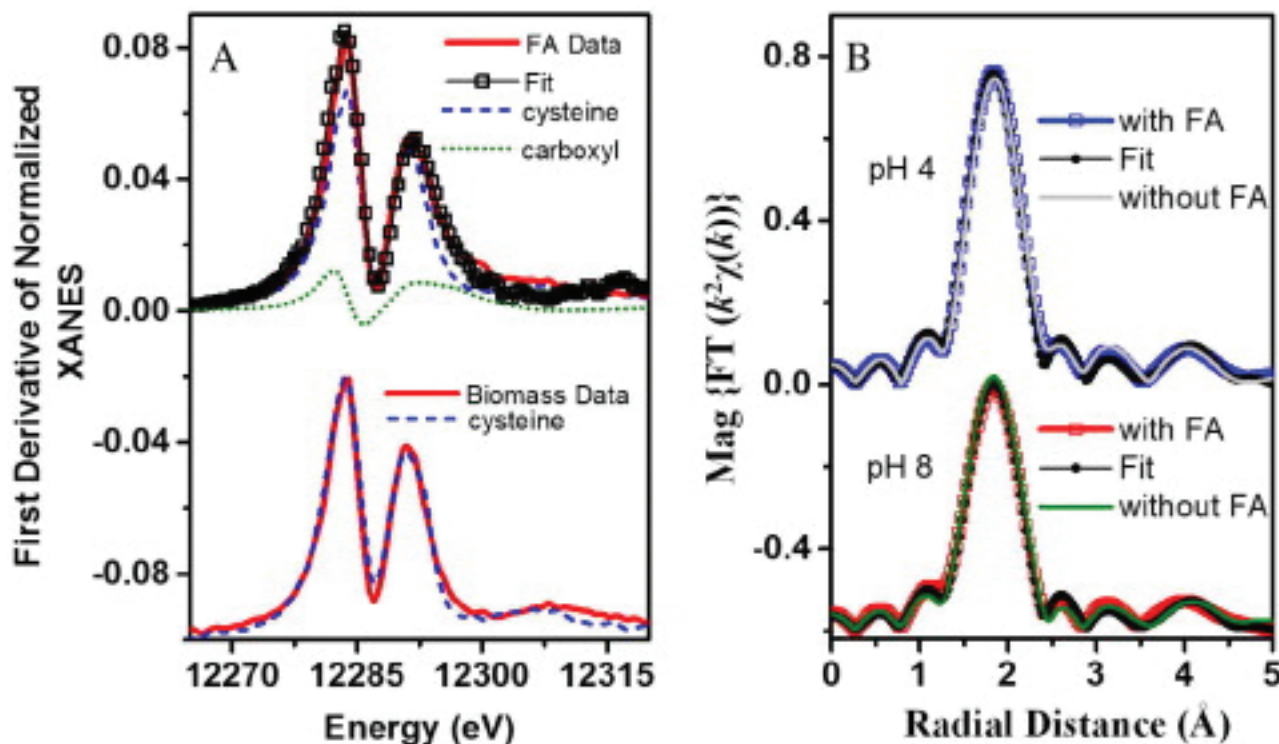


Fig. 1. (a) Linear combination fitting of the first derivative of the Hg–FA XANES data plotted with components. The first derivative of the Hg–biomass data is shown with the Hg–cysteine standard only. (b) EXAFS Fourier transform (FT) data of the Hg–biomass data with and without fulvic acid at pH 4 and 8 overlaid with corresponding fits.

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adsorb to FA in a competitive ligand effect, leaving less mercury available for functional groups on the cell walls and, in the end, less mercury is removed from the solution. This isn't surprising, say the researchers: FA molecules contain sulfhydryl groups within their structure and sulfhydryl groups bind strongly with Hg.

Next, the team was curious to know which functional groups mercury bound to. To determine if mercury preferred binding to one site over another, they conducted x-ray absorption spectroscopy experiments at three pH conditions.

Again using the 10-ID-B and 9-BM-B,C beamlines, the team found the mechanism mercury uses to bind to bacteria does not change in the presence of FA (Fig. 1). This essentially rules out any possibility of mercury, FA and bacteria forming ternary complexes, at least under the conditions studied.

Members of the team are continuing their investigations into conditions and chemical environments that may favor mercury clean up.

— *Danielle Venton*

See: Sarah Dunham-Cheatham¹, Bhoopesh Mishra², Satish Myneni³, and Jeremy B. Fein¹, “The effect of natural organic matter on the adsorption of mercury to bacterial cells,” *Geochim. Cosmochim. Acta* **150**, 1 (2015). DOI: 0.1016/j.gca.2014.11.018

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