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A Better Method for Evaluating Heavy Metal Water Pollution

Janet Hering
California Institute of Technology

Background

High concentrations of heavy metals, and even trace amounts of some, can be harmful to both plants and animals. The toxicity of heavy metal contamination, however, is highly dependent on the chemical form of the metal in question. For instance, in general, metals that are bound in particles or to organic (carbon-containing) compounds are less toxic than dissolved free ions, less toxic meaning that the metals are less readily available for uptake by marine organisms.

Traditionally, efforts to control heavy metal pollution have focused on monitoring the "total recoverable" or "total dissolved" fraction of a metal in seawater samples. In quantifying these fractions, water samples are mixed with a strong acid. The sample is vaporized and ionized, and typically a beam of light is then passed through the sample. The amount of light absorbed by the sample gives an estimate of the amount of the metal. Although this method, called atomic absorption spectroscopy, is relatively straightforward and inexpensive, it does not discriminate among different chemical forms of metal-containing compounds, and thus it does not directly evaluate the toxicity of contamination. This means that it rarely provides a good prediction of the human or environmental health risks associated with contamination.

The Project

In this project, Dr. Janet Hering, an environmental engineering professor at the California Institute of Technology, was funded to begin to develop the tools that one day will make it possible to measure the bioavailable fraction of metal pollution in seawater. For the project, Dr. Hering used chromatography coupled with mass spectrometry to separate and quantify organic complexes of copper and nickel in idealized, laboratory conditions.

In this method, the sample is injected into a plasma, where it is vaporized and ionized. Metal ions are then sent to a mass spectrometer which sorts the ions according to their atomic mass. Those ions with an atomic mass corresponding to the metal compound in question are then measured.

Underscoring the challenges of evaluating the bioactive component of heavy metal pollution, Dr. Hering found that her method is not yet sensitive enough to measure metal compounds in water samples collected from coastal waterways.

She cited the rapidity with which metals are exchanged among organic compounds as being one factor that makes measuring heavy metal pollution a moving target.

Applications

Progress in developing instruments that can speciate different



It takes very complex instrumentation to measure the different metal-containing compounds in water. Here is an instrument used by Dr. Janet Hering of the California Institute of Technology to measure copper and nickel in laboratory water samples. Photo: California Institute of Technology.

metal-containing compounds is a first step toward being able to determine the bioavailable fraction of metal contamination. From a policy-making standpoint, these tools are what are needed to refine existing regulations.

The ability to measure the bioavailable fraction of heavy metal contamination would also help communities evaluate their water quality (in marinas and harbors, for instance, where antifouling hull paints contribute to copper pollution), identify sources of contamination and prioritize cleanup efforts based on their relative toxicity to the environment.

Publications

Piatina, T.B., and J.G. Hering. 2000. Direct quantification of metal-organic interactions by size-exclusion chromatography (SEC) and inductively coupled plasma mass spectrometry (ICP-MS). *J. Environ. Qual.* 29:1839–1845.

Trainee and Thesis

Piatina, Tatiana, Ph.D, California Institute of Technology, June 2001, "Studies of Metal-Organic Interactions with Model Synthetic and Natural Ligands Applicable to Natural Waters."

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