Canadian Network of Toxicology Centres

Metals In The Environment Research Network

SCIENCE BRIEF (June 2004)

DETERMINING THE BIOAVAILABILITY OF METALS IN SURFACE FRESHWATERS

ISSUE

Speciation of metals (distribution into different chemical forms) in aquatic systems controls both their bioavailability and their toxicity. Metal speciation studies in freshwater have historically focused on the role of organic matter in oxic (containing oxygen) surface waters, and sulphur in anoxic (lacking oxygen) bottom waters. Relatively recent research had shown that sulphide can also be important in determining metal speciation in oxic surface waters. However, little was known about metal-sulphide species in these waters, or their relative importance in controlling metals bioavailability and toxicity.

SIGNIFICANCE

This research, which was focused on the Canadian Shield, has confirmed that reduced sulphur metal species (forms) do occur in oxic surface freshwaters in the forms of metal-sulphide complexes and colloids. However, truly dissolved metal-sulphide complexes play an insignificant role in determining metal speciation in these waters. Although research is continuing focused on metal-sulphide colloids, the present findings confirm that the focus of metal speciation studies in oxic surface freshwaters should be on the role of organic matter.

BACKGROUND

Other researchers published novel findings indicating that metal-sulphide species were not confined to anoxic waters, but were also found in oxic waters. These findings cast doubt on the present world-wide research emphasis on organic matter as a determinant of metal speciation in oxic freshwaters. Accordingly, this project was initiated to answer three specific questions: (1) Can metal-sulphide species exist in a stable form in oxic freshwaters?; (2) If they can, what are their chemical identities – are they complexes, clusters or colloids?; (3) How important are they in determining metal

speciation in surface waters on the Canadian Shield?

FINDINGS

This research, carried out through the Metals in the Environment Research Network (MITE-RN), answered the above three questions as follows. (1) Whereas some metal-sulphide species (e.g., Fe-S, Mn-S, Ni-S) are not stable in oxic waters, other metal-sulphide species (e.g., Pb-S, Zn-S, Cd-S, Cu-S) can be stable in oxic waters for weeks to months. (2) Oxidation-resistant metal-sulphide species in laboratory solutions are indeed a mixture of truly dissolved metal-sulphide complexes and dynamic colloids; they are not soluble metal-sulphide nanoclusters (very small colloids) as previously reported in the literature. (3) Field studies and thermodynamic modeling indicate that truly dissolved metal-sulphide complexes play a negligible role in determining metal speciation in surface waters on the Canadian Shield. Revised metal speciation models have been developed to assess metal speciation in waters where sulphide concentrations are relatively high, including sediment pore waters.

FUTURE RESEARCH

New analytical techniques are needed to determine the relative importance of dynamic metal-sulphide colloids in surface waters. Although metal-sulphide nanoclusters are not found in synthesized oxic waters, they may be present in natural surface waters if appropriate stabilizing agents are available. Although these metal species probably do not contribute significantly to metal bioavailability or toxicity, this possibility warrants further investigation.

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ADDITIONAL INFORMATION

P. M. Chapman, F. Wang, J .D. Germano and G. Batley. 2002. Pore water testing and analysis: The good, the bad, and the ugly. Marine Pollution Bulletin, volume 44, pages 359 to 366.

C. DeVries and F. Wang. 2003. In situ two-dimensional high-resolution profiling of sulfide in sediment interstitial waters. Environmental Science and Technology, volume 37, pages 792 to 797.

P. M. Chapman, F. Wang, C. J. Janssen, R. R. Goulet and C. N. Kamunde. 2003. Conducting ecological risk assessments of inorganic metals and metalloids: Current status. Human and Ecological Risk Assessment, volume 9, number 4, pages 641 to 697.

K. Sukola, F. Wang and A. Tessier A. 2004. Metal-sulfide complexes in oxic waters: Complexes, colloids, or clusters? Environmental Science and Technology (in review).

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http://www.mite-rn.org/research/era/era.shtml