Canadian Network of Toxicology Centres

Metals In The Environment Research Network

SCIENCE BRIEF (June 2004)

TOXICITY OF METAL MIXTURES IN AQUATIC ENVIRONMENTS

ISSUE

Management decisions regarding metals in the aquatic environment rely primarily on assessments of the toxicity of individual metals. However, metals in the environment are almost always present as mixtures of different metals (and other substances). The toxicity of individual metals does not provide a high level of certainty in predictions of the toxicity of mixtures of metals. There have been relatively few studies that assess and compare the toxicity of individual metals to those of mixtures, and there presently is no clear guidance as to how the toxicity of metal mixtures should be assessed in the aquatic environment. Such information is crucial to ensuring adequate environmental protection.

SIGNIFICANCE

This research has provided increased certainty regarding metal interactions in the environment. A specific approach for dealing with metal mixtures in aquatic environments has been proposed for screening purposes, along with specific recommendations for more detailed assessments. An effects addition model is being developed that predicts chronic toxicity based on metal concentrations in the body of a benthic (bottom-dwelling) invertebrate (an animal without a backbone) that is both ecologically important and widely used as a "laboratory white rat". The results of this research are providing managers and regulators with more reliable predictions of impacts from metal mixtures in the environment.

BACKGROUND

Mixtures of metals are commonly encountered in the natural environment as a result of both natural processes and human activities. Although research has been conducted into metal mixtures previously, two key questions remain unanswered. First, to what extent do individual metals contribute to any toxicity? Second, is toxicity significantly greater or lesser than the sum of the toxicities of the individual metals?

There are two available models, encompassing a range of graphical, mathematical, and statistical methods, which are used

to predict both the toxicity of metal mixtures and the interactions of individual metals: Concentration Addition (CA) and Effects Addition (EA). In CA all metal concentrations in a mixture are added together to predict toxicity, after accounting for different potencies, as if the metals all have the same site(s) and mechanism(s) of action. In EA the effects, rather than concentrations, of metals are added, as expected if all metals act totally independently. In both models, mixtures toxicity may be additive (equal to the summed toxicity of the individual metals), more than additive, or less than additive. However, there has been no evaluation of the published literature to determine the frequency of occurrence of each of these three possible toxicity responses to mixtures of metals. Nor have there been studies that determine the toxicity of a wide range of metal mixtures to organisms, and which provide predictions of toxicity based on metal body burdens.

FINDINGS

This research, carried out through the Metals in the Environment Research Network (MITE–RN) program, has provided guidance regarding the use of models to predict metal mixture toxicity. Based on the published literature, assumptions of additivity were overprotective in 43% of cases (less than additive), appropriately protective in 27% of cases (additive), and underprotective in 29% of cases (more than additive). Until more robust models are developed, the most appropriate approach is to conduct a toxicity assessment of the mixture as present in the environment. Toxicity tests should include measurement of body burdens of metals (to determine which metals are bioavailable to organisms). When both model predictions and laboratory tests suggest toxicity in the environment, the health of resident communities should be assessed.

The toxicity of metal mixtures (10 metals) has been determined to the aquatic amphipod *Hyalella azteca*. This amphipod is widely used as a “laboratory white rat” and has significant ecological relevance in many freshwater environments. Lethal body concentrations have been determined and could form the basis for environmental quality guidelines for aquatic toxicity based on metal body burdens (12 metals), rather than on concentrations in the ambient environment.

CONTINUING RESEARCH

Ongoing research focuses on predicting the effects of metal mixtures based on critical body concentrations. The primary focus is on integrating the toxicity : accumulation functions of each metal into a metal mixture model, which will further increase the certainty of predictions regarding effects of metal mixtures in the aquatic environment.

ADDITIONAL INFORMATION

W. P. Norwood, U. Borgmann, D. G. Dixon and A. Wallace. 2003. Effects of metal mixtures on aquatic biota: a review of observations and methods. Human and Ecological Risk Assessment, volume 9, number 4, pages 795 to 811.

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