



SCIENCE BRIEF (June 2004)

PROTECTING FRESHWATER ANIMALS FROM METAL TOXICITY

ISSUE

Freshwater invertebrates (animals without a backbone such as insects and worms) are key links in the food chains of lakes and streams. Metals can affect the health of these animals and thus of the predators that depend on them. Conventional wisdom has been that invertebrates living in sediments will be protected by sediment quality guidelines, while those living in the water column will be protected by water quality guidelines. However, sources of metals to invertebrates have not been well defined, thus this “conventional wisdom” remained to be proven.

SIGNIFICANCE

This research has shown that some sediment-dwelling organisms take up metals primarily from the overlying water column, not from the sediments in which they live. Thus, sediment quality guidelines and criteria may not necessarily protect these organisms from harm. Similarly, some organisms dwelling in the water column take up metals primarily from their food, not from the water. Thus, water quality guidelines and criteria may not necessarily protect them. Based on the results of this research, guidelines and criteria for the protection of aquatic invertebrates can be improved and refined so that an appropriate degree of environmental protection from exposure to metals is afforded to invertebrates and the predators that depend on them.

BACKGROUND

Governments around the world depend on water and sediment quality guidelines or criteria for the protection of organisms and ecosystems from toxicity due to metals (or other contaminants). These guidelines or criteria are based on simplistic assumptions regarding routes of exposure – if you live in the sediments, you are exposed via the sediments; if

you live in the water column, you are exposed via the water. However, some organisms living in sediments pump water through U-shaped burrows and thus are more exposed to metals in the overlying water column than metals in sediments. Similarly, some animals living in the water column take up metals primarily from food rather than from water. However, these very real differences have been generally ignored in the development of simplistic environmental quality guidelines or criteria and even in detailed ecological risk assessments.

FINDINGS

This research, carried out through the Metals in the Environment Research Network (MITE–RN) program, has shown that freshwater animals themselves determine how metals may affect them through their burrowing and feeding behaviors. For instance, in the case of some sediment-dwelling invertebrates, the overlying water column is more important as a metal source for insects, whereas the sediment compartment is more important for worms. Some predatory insects are exposed to metals primarily through their prey. These very real environmental complexities can be integrated into laboratory tests, environmental quality guidelines or criteria, and into risk assessment protocols, which will improve the ability of these tools to protect freshwater aquatic ecosystems from toxicity due to metal contamination.

FUTURE RESEARCH

Knowledge of metal uptake routes is important in predicting toxicity because uptake sites such as the gut and gills can and do differ in their affinities for metals and their sensitivities to metals. Further improvements to toxicity predictions require multi-compartment models to describe metal uptake. Ideally, information used by these models should include the forms of metals in cells – some metals in cells are effectively sequestered or rendered inert. A key question remaining to be addressed is whether or not toxic effects occur at the same concentration in an animal regardless of the route of uptake and the history of exposure. Finally, the above research has focused on freshwater ecosystems; similar research is required for marine and estuarine ecosystems.

ADDITIONAL INFORMATION

Overview Information:

L. Hare, A. Tessier and U. Borgmann. 2003. Metal sources for freshwater invertebrates: pertinence for risk assessment. Human and Ecological Risk Assessment, volume 9, number 4, pages 779 to 793.

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

Other Information:

- U. Borgmann, M. Nowierski, L. C. Grapentine, and D. G. Dixon. 2004. Assessing the cause of impacts on benthic organisms near Rouyn-Noranda, Quebec. *Environmental Pollution*, volume 129, pages 39 to 48.
- A. Gosselin and L. Hare. 2004. Effect of sedimentary cadmium on the behavior of a burrowing mayfly (Ephemeroptera, *Hexagenia limbata*). *Environmental Toxicology and Chemistry*, volume 23, pages 383 to 387.
- U. Borgmann. 2003. Derivation of cause-effect based sediment quality guidelines. *Canadian Journal of Fisheries and Aquatic Sciences*, volume 60, pages 352 to 360.
- 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, pages 795 to 811.
- M. N. Croteau, L. Hare and P. Marcoux. 2003. Feeding patterns of migratory and non-migratory *Chaoborus* species in an acidic and metal contaminated lake: importance of prey ingestion rate in predicting metal bioaccumulation. *Archives für Hydrobiologie*, volume 158, pages 57 to 74.
- M. N. Croteau, L. Hare and A. Tessier. 2003. Difficulties in relating Cd concentrations in the predatory insect *Chaoborus* to those of its prey in nature. *Canadian Journal of Fisheries and Aquatic Science*, volume 60, pages 800 to 808.
- M. N. Croteau, L. Hare and A. Tessier. 2002. Influence of temperature on Cd accumulation by species of the biomonitor *Chaoborus*. *Limnology and Oceanography*, volume 47, pages 505 to 514.
- M. N. Croteau, L. Hare and A. Tessier. 2002. Increases in food web cadmium following reductions in atmospheric inputs to some lakes. *Environmental Science and Technology*, volume 36, pages 3079 to 3082.
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- M. N. Croteau, L. Hare and A. Tessier. 2001. Explaining differences in Cd content among species of the lake-dwelling biomonitor *Chaoborus*. *Canadian Journal of Fisheries and Aquatic Sciences*, volume 58, pages 1737 to 1746.
- L. Hare, A. Tessier and L. Warren. 2001. Cadmium accumulation by invertebrates living at the sediment-water interface. *Environmental Toxicology and Chemistry*, volume 20, pages 880 to 889.
- F. Wang, A. Tessier and L. Hare. 2001. Oxygen measurements in the burrows of freshwater insects. *Freshwater Biology*, volume 46, pages 317 to 328.

C. Munger and L. Hare. 2000. Influence of ingestion rate and food types on Cd accumulation by the aquatic insect *Chaoborus*. Canadian Journal of Fisheries and Aquatic Sciences, volume 57, pages 327 to 332.

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