Science Brief January 2009—Issue 03

Metal Transfer Along Aquatic Food Chains

MITHE-SN • CANADIAN NETWORK OF TOXICOLOGY CENTRES

Research of Benefit to Canadians

Researchers have shown that to understand and predict contaminant accumulation and effects on animals, it is necessary to measure contaminants in both the water and the food to which the animals are exposed. Thus, comparing contaminant concentrations in fish to those in water could be misleading because such an approach ignores the many processes taking place as contaminants move along food chains to reach this top consumer. Such information is essential to assess the risk of contaminants and to establish regulations that will protect the life in lakes and rivers and the health of human and other animals that depend on these systems for their food.

Graduate students from INRS-ETE in Québec City, Dominic Ponton (standing) and Isabelle Proulx (sitting), spent several weeks this summer collecting sediment, water, and insects from lakes located both near mining operations and in pristine areas to determine if insects can be used to monitor metal concentrations in lakes.

Tracking Trace Metals Along Food Chains

Developing regulations that protect human and ecosystem health depends on predicting the concentrations of potentially-toxic elements in organisms, their effect on the organisms, and the amounts transferred along food chains to other organisms. Current risk assessments for aquatic ecosystems are often based solely on the concentration of contaminants in water and do not include those that enter the food chain through the diet of animals.

Explaining and predicting trends in metal concentrations along food chains is critical for assessing risk to animals

The Metals in the Human Environment Strategic Network (MITHE-SN) is funding a project that examines the accumulation of metals in algae and their subsequent transfer from algae (as well as from sediments) to animals in the food chains of lakes. The information collected will improve predictions of trace metal transfer along food chains and risk assessments for aquatic ecosystems. The researchers are concentrating their efforts on four elements of environmental concern: cadmium, nickel, selenium and thallium.

Starting at the Bottom of the Food Chain

The researchers have created food chains that are based on either algae or sediments, both of which are consumed by various small animals (crustaceans, insects, or worms) that are in turn eaten by predatory insects. All of these consumers can then be preyed upon by fish, which are a source of food (and contaminants!) for birds, mammals, and humans.

Not all of the contaminants in algae or sediment will be passed on to consumers. In the case of algae, the proportion moving up the food chain will depend on whether the consumer is able to break open the algal cells in its gut. The researchers discovered that whereas 99% of the cells of one species were easily broken, the comparable figure for another was only 27%. Thus the types of algae present in a lake are likely to influence the ease with which contaminants at the base of the food chain are transferred to animals. The researchers are now studying what happens once the algal

What controls the transfer of contaminants from algae to herbivores?

cells are broken open in the gut of a consumer. They are asking the question: does the way in which contaminants are bound to various algal cell fractions influence the proportion that will be taken up by the consumer?

Moving Along the Food Chain

Some insects and worms take up contaminants from the mud on which they feed. The researchers have discovered that contaminants in these "mud-eaters" are transferred to their predators, and the proportion transferred depends on how the contaminants are bound in prey cells. For example, when a predatory alderfly consumes such prey, it assimilates most of the cadmium, nickel, selenium and thallium that they contain. The researchers were able to explain this highly efficient transfer from prey to predator when they discovered that these contaminants are not tightly bound in the cells of prey and thus are readily liberated when

Transfer of contaminants from prey to predators depends on how they are bound in prey cells

digested in the predator's gut. The researchers have also found that measurements of metals in prey and predators are useful for ranking lakes according to their contamination level.

At the Top of the Food Chain

Fish are the top predators in the researcher's experimental food chains. To learn from where fish get their contaminants, the researchers exposed larval and juvenile fathead minnows to nickel or thallium in either water or the diet or both. While fish larvae took up these metals from water alone, juveniles took them up about equally from water and their food. This result suggests that ignoring the contribution of dietary metals, would substantially underestimate metal accumulation in juvenile fish. The researchers are now working to understand the factors controlling nickel and

Fish take up nickel from both their diet and water

thallium uptake from the diet. Lastly, although the nickel taken up by fish did not kill, them there were effects because it took less time for their eggs to hatch at high nickel concentrations.

This research is supported by the NSERC Metals in the Human Environment Strategic Network (MITHE-SN); lead investigator is Dr. Landis Hare and co-investigators are Drs. Peter Campbell, Patrice Couture, and Claude Fortin along with their graduate students (all of whom are at INRS-ETE, Université du Québec).

About MITHE-SN

The **Metals in the Human Environment Strategic Network** is a collaboration of academia, government, and industry. The Network conducts research in support of science-based environmental and human health risk assessments for metals in water, soil, and food, within well articulated and planned inter-disciplinary research themes. Our research program is strongly linked across Canada, with field sites in the Maritimes, Québec, Ontario, The Prairies, British Columbia, the Yukon, and Nunavut. The Network also features strong links among academic and government scientists. Implicit in the MITHE-SN approach is a commitment to joint, interactive, centralized planning, project accountability for both intellectual and financial objectives, and regular reporting of research progress beyond the usual publication in scientific journals.

Reference Link: **www.mithe-sn.org** Telephone: **519-824-4120**, Ext. **52950**
MITHE-SN Secretariat, Canadian Network of Toxicology Centres, University of Guelph