

Challenges in RA
Environmental Bioavailability in Risk Assessment
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It is widely recognized that bioavailability is crucial for the understanding of environmental metal toxicity. Recently, in the frame of the ongoing EU metal Ras, the EU Member states agreed to evaluate and incorporate bioavailability into the risk analysis of metals in water and sediments compartments.

For the aquatic compartment, metal bioavailability and metal toxicity depends on (1) the partitioning of the metal to the suspended solids, (2) the speciation of the metal within the dissolved phase and (s) the competition between the free ions for the biological binding sites (the Biotic Ligands). The recently developed Biotic Ligand Model (BLM) integrates the existing knowledge on metal speciation, metal competition and metal toxicity and allows to predict the bioavailability and toxicity of metals to aquatic organisms belonging to different trophic levels under varying water chemistry conditions. The model is currently under review by regulatory agencies in the United States, South America and Europe. For copper for example, acute and chronic BLMs were developed and evaluated/validated across a variety of EU surface waters. Application of the models to copper ecotoxicity data, collected from recent research as well as available literature data, showed that between 50% and 90% of the intra-species variability observed in the aquatic ecotoxicity data can be reduced by the application of the BLMs. Subsequent application of the BLMs to the freshwater copper exposure and effects databases allows to express effects and exposures on the same level of bioavailability and leads to important reductions in uncertainty of the risk analysis.

For the sediment compartment, especially the binding of divalent metal ions to the sulphides present in anaerobic sediments is important for the understanding of metal bioavailability in sediments. Again, incorporation of the metal-sulphide binding into the risk analysis can drastically reduce the uncertainty related to the assessment of metal toxicity in sediments and hence increase the ecological relevance of the risk assessment.

Towards improving approaches for estimating risk to freshwater invertebrates

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The Canadian Environmental Protection Act (1999) requires that the persistence (P), bioaccumulation (B) and inherent toxicity (iT) of the 23,000 substances on Canada's Domestic Substances List be evaluated by September 2006. Substances that meet the specified PBiT criteria must undergo screening level risk assessments. Compounds of several trace metals will be identified as requiring screening assessments through this process.

Evaluation of risks begins with a problem formulation phase, which includes preliminary examination of data on releases and presence in the Canadian environment, and identifying sensitive aquatic and terrestrial assessment endpoints. This is followed by an analysis phase, involving detailed evaluation of information on entry, exposure and effects. Exposure concentrations (or Estimated Exposure Values) are determined for each assessment endpoint. Corresponding low effect concentrations (or Critical Toxicity Values) are also determined. Generally chronic effects are of most interest, with the preferred measure being EC25s for effect with population level significance. Effect thresholds (or Estimated No Effect Values) are derived by dividing Critical Toxicity Values by an application factor, to give a value with a very low probability of causing effects. Risk is evaluated by comparing the Estimated Exposure Value (EEVs) to the corresponding Estimated No Effect Value (ENEVs). If the EEV exceeds the ENEV (i.e., if risk quotient > 1.0), opportunities for increasing the realism of exposure and effect estimates are explored. If realistic risk quotients exceed 1.0, there is potential for environmental harm. A probabilistic risk analysis may then be undertaken, involving comparison of exposure and effects distributions to determine the likelihood of adverse effects.

The main objective of an ecological risk assessment (ERA) is to evaluate the effects of contaminants on the structure of food chains. Because of this, evaluation of risk relies heavily on the selection of the most sensitive species. Aquatic invertebrates can be very sensitive to metals. In addition, they provide a link between primary producers and fish along the food chain. Hence, the disappearance of these animals can lead to adverse effects on top predators, and affect the structure of the food web. In current risk assessment methods, water is considered the main source of metals to aquatic invertebrates. However, literature data show that food is an important source of metals depending on the type of metal. Therefore, risk assessments need to consider the food pathway when evaluating metal exposure to sensitive freshwater invertebrates. In this study, we investigated the possibility of using a dynamic multipathway bioaccumulation model (DYMBAM) to evaluate the risk of metal exposure to freshwater invertebrates in the Canadian environment. The DYMBAM has the advantage of considering both water and food as a source of metal to invertebrates and is a definite upgrade from current models used in risk assessment. At present, the integration of the DYMBAM in ERA methods is limited by the availability of field data. An alternative approach is proposed to overcome this problem. Funding is provided by the MITE-RN, Environment Canada and an NSERC PDF to R.Goulet.

DELINEATING pathways of metal accumulation in freshwater fish: improving uptake predictions for ecological risk assessment of metals

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Ecological risk assessment (ERA) involves assessment of exposure and effects of contaminants of concern. Fish (and other aquatic biota) can potentially take up metals from water and food. However, few studies have quantified the relative importance of food and water as sources of metals to fish, possibly due to the complexity of distinguishing metals accruing from either source once assimilated by the animal. Kinetic models can be used to quantify the relative importance of the pathways of metal exposure and for site-specific predictions of metal concentrations in aquatic organisms. We developed kinetic bioaccumulation models for copper, zinc, and cadmium using laboratory data generated within MITE-RN, and other relevant data available from literature. The kinetic models were then used to calculate site-specific metal accumulation in yellow perch under natural conditions, and to quantitatively compare the relative importance of uptake pathways to the overall body metal burden. Model predictions of the concentrations of copper, zinc, and cadmium in fish corresponded reasonably well with measured values, suggesting that the models accounted for most of the factors governing accumulation. Laboratory-derived numerical values of model parameters were reasonably applicable across fish species and in natural waters. Free metal concentration best predicted metal accumulation from the dissolved phase, whereas metal assimilation efficiency from food depended on the metal concentration in the diet. Generally, under the conditions of exposure in metals-contaminated lakes, the dietary pathway was dominant for copper and cadmium uptake whereas water was the main pathway for zinc uptake. (Supported by MITE-RN and EVS Environment Consultants).

Nickel EU Existing Substances Risk Assessment: Status update and research Program

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Risk assessments for both new and existing substances are currently required in the EU as a result of Council Directive 67/548/EEC (as amended for the 7th time by Directive 92/32/EEC) and Council Regulation (EEC) No. 793/93. These assessments must include risk to both human health and the environment. Metallic nickel and nickel sulfate were nominated to the 3rd Priority List while nickel dichloride, nickel carbonate and nickel nitrate were nominated to the 4th Priority List of Existing Substances. Denmark was selected as the rapporteur country for the mandated risk assessments of these compounds.

The first drafts (April 2002) of the Danish aquatic and terrestrial risk assessment chapters include calculations for PNECs (predicted no effect concentrations) for nickel that are below background levels in all compartments. The aquatic PNEC has been proposed at the part per trillion or PPT range. Due to limited data availability, the Danish EPA was unable to account for the differences in nickel toxicity as a result of the influence of abiotic factors such as hardness and Ph. Therefore, the data sets could not be normalized to reduce the variability between studies, and bioavailability as a function of these factors was not applied in the assessment.

A research plan aimed at understanding the interaction of nickel with the environment and the factors that contribute to both increased and decreased nickel toxicity was developed for each of the environmental compartments. The objectives in each plan are to generate additional chronic test data for nickel, quantify the effect of abiotic factors on the toxicity of nickel, field validate the data collected, and incorporate the findings in a regulatory risk assessment framework. In this presentation, an update will be given on the draft effects assessment and the industry-sponsored research program to fill data gaps for nickel.