THE FUTURE OF METAL MIXTURE REGULATIONS

Fact Sheet Five

Introduction

Considerable progress has been made over the past five years in improving our understanding of the potential effects of metal mixtures on aquatic systems and in the development of tools that will allow regulation of metal mixtures in the future. A large number of toxicity studies have been conducted expanding the number of species and metal mixture combinations for which we now have data. There have also been advances in our understanding of how best to statistically analyse mixture data and there has been the initial development of mixture Biotic Ligand Models (mBLMs) that can predict the toxicity of metal mixtures.

While this progress is encouraging, additional research and development may be needed to address specific regulatory and management issues related to metal mixtures in a scientifically robust manner. This factsheet highlights some key questions that regulatory jurisdictions will need to confront in order to develop approaches for regulating metal mixtures.

What is the most appropriate mBLM modelling framework?

Currently there are several different mBLM models available. These models all have the same general structure, using chemical speciation to predict metal accumulation at a ligand and then relating the ligand-accumulated metal to toxicity. However, there are differences in key components of the model framework such as the chemical speciation model used, the specific mechanisms of the interactions, the number of metal binding sites, and the dose response model applied. Decisions regarding the most appropriate model assumptions for regulatory implementation will ultimately drive further development of mBLMs for specific regulatory regimes.

Are responses to acute and chronic metal mixtures consistent?

The majority (~90%) of metal mixture toxicity studies to date have evaluated acute (i.e. short-term, lethal effects) exposures; however, many regulatory jurisdictions focus on chronic (long-term, sub-lethal effects) toxicity. Although the current sample size for chronic metal mixture studies is small, evidence suggests that, in general, chronic responses to metal mixtures (metal combinations, mixture interaction types, etc.) follow the same trend as those seen in acute studies. To this end, newer metal mixture studies have been focused on better characterizing chronic exposures and incorporating such results into mBLM frameworks.

How many metals should be assessed in mixture regulations?

While the majority of metal mixture toxicity data has been collected for binary mixtures, some data for higher-order mixtures (ternary and quaternary) are also available. Similarly, mBLM development to date has largely focussed on binary mixtures; however, the modelling framework has been applied to higher-order mixtures and can conceptually be applied to any combination of metals for which single-metal BLMs exist. This raises questions regarding relative concentrations and ratios of metals that should be considered in mixture-based regulations in the future. For example, the frequency and magnitude of certain metal combinations change when considering natural or anthropogenic (wastewater discharge) sources. In addition, metals may be present at differing levels of their respective individual effect concentrations (e.g., 80, 10, or 1% of their LC50 or EC10). It is unclear at this time at what concentration a given metal in a mixture should be considered as a contributing factor to toxicity. For example, will 10 metals occurring at a concentration causing a 1% effect lead to a 10% effect (i.e., EC10)? There have been significant advances in our understanding of how metal mixtures affect aquatic organisms and our ability to predict those effects.

What questions remain regarding development of metal mixture regulations?

Although the development and validation of mBLMs are continually advancing, several uncertainties must be addressed in order to implement robust, science-based approaches for developing Water Quality Guidelines (WQG) and performing environmental risk assessments for metal mixtures. These include:

- How will a multi-metal WQG be implemented?
- Will the WQG be based on a predicted effect level for the mixture?
- Will reduction in concentrations of one metal allow for increases in another metal as long as the mixture is not toxic?
- If the mixture WQG is exceeded, how will decisions be made on which metals within the mixture must be reduced in concentration?

Summary and conclusions

There have been significant advancements in our understanding of how metal mixtures effect aquatic organisms and our ability to predict those effects. However, important questions remain to be answered as regulatory agencies begin developing tools and regulatory frameworks for metal mixtures in the aquatic environment. Collaborative interactions between regulators, industry, and scientists will be needed as the development of metal mixture regulations progresses.