Consideration of Metal Availability and Fate in Life Cycle Assessments (LCA)

Presented at the Workshop on LCA and Metals

Theme 3: Life Cycle Impact Assessment (LCIA): Human and Environmental Toxicity of Metals

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-- ABSTRACT --
Consideration of Metal Availability and Fate in Life Cycle Assessments

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An important step in a Life Cycle Assessment (LCA) for a product is the Impact Assessment (IA). The purpose of the IA is to examine potential and actual environmental and human health effects that result from releases of materials, be they organic chemicals, metals or metal compounds, to the environment. While the magnitude of the mass loading rate of a substance to the environment is likely to be an important factor in the IA, it should be viewed in combination with other factors that affect its potential for causing effects. This is because there are likely to be complex interactions of the substance with numerous environmental factors, and these interactions may alter its availability to biota and its ultimate environmental fate as well. The significance of such factors will vary by substance, and hence it is important that they not be disregarded in the LCA, especially if cross-product comparisons are to be made. Fortunately, methods are available for use by the LCA analyst that will facilitate the incorporation of such considerations into an LCA. The biological availability of a metal that is released to a terrestrial or aquatic system is particularly likely to be influenced by the physical-chemical characteristics of a particular medium. Hence it is important to consider the factors that affect metal availability, to the degree possible. The biotic ligand model (BLM) is an example of a computational tool that is being developed for use in performing an assessment of metal availability and toxicity in the water column of aquatic systems, and its potential for use in benthic sediments and terrestrial settings is under consideration as well. Further, while metals are often viewed as being conservative, in that the ultimate degradation to an end product such as CO_2 does not occur, failure to consider that the exposure levels of the available metal forms will likely decrease over time will detract from the validity of an LCA. A unit world model framework for metals is proposed as a way to quantitatively consider these factors in the context of an LCA. Use of this type of approach should facilitate the completion of meaningful assessments of exposure levels and the potential for effects. While the results of such an evaluation should ultimately be of use in making cross-product LCA comparisons, methods for integrating the results across impact categories, and for making such comparisons generally, require further development.

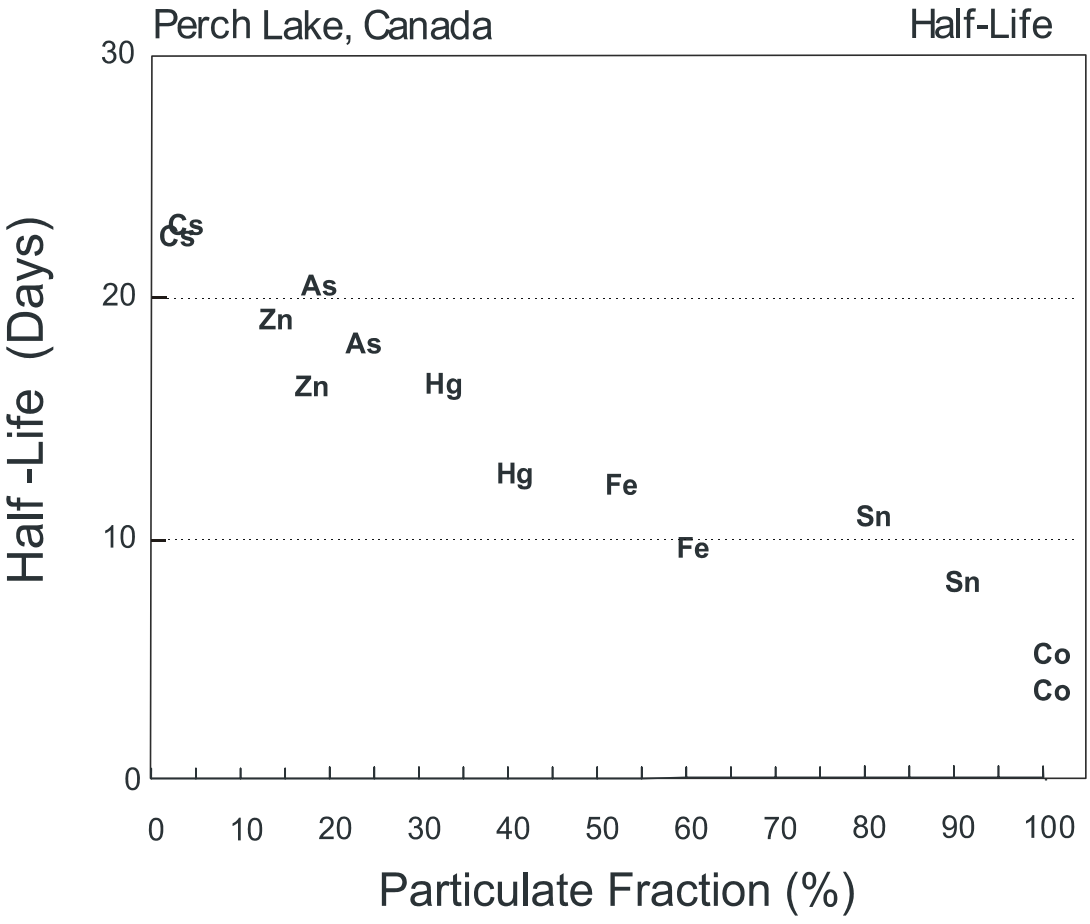


Figure 10. Mesocosm - Lake: Summary of Half-life Versus Particulate Fraction, Perch Lake, Canada (data from Diamond et al., 1990)

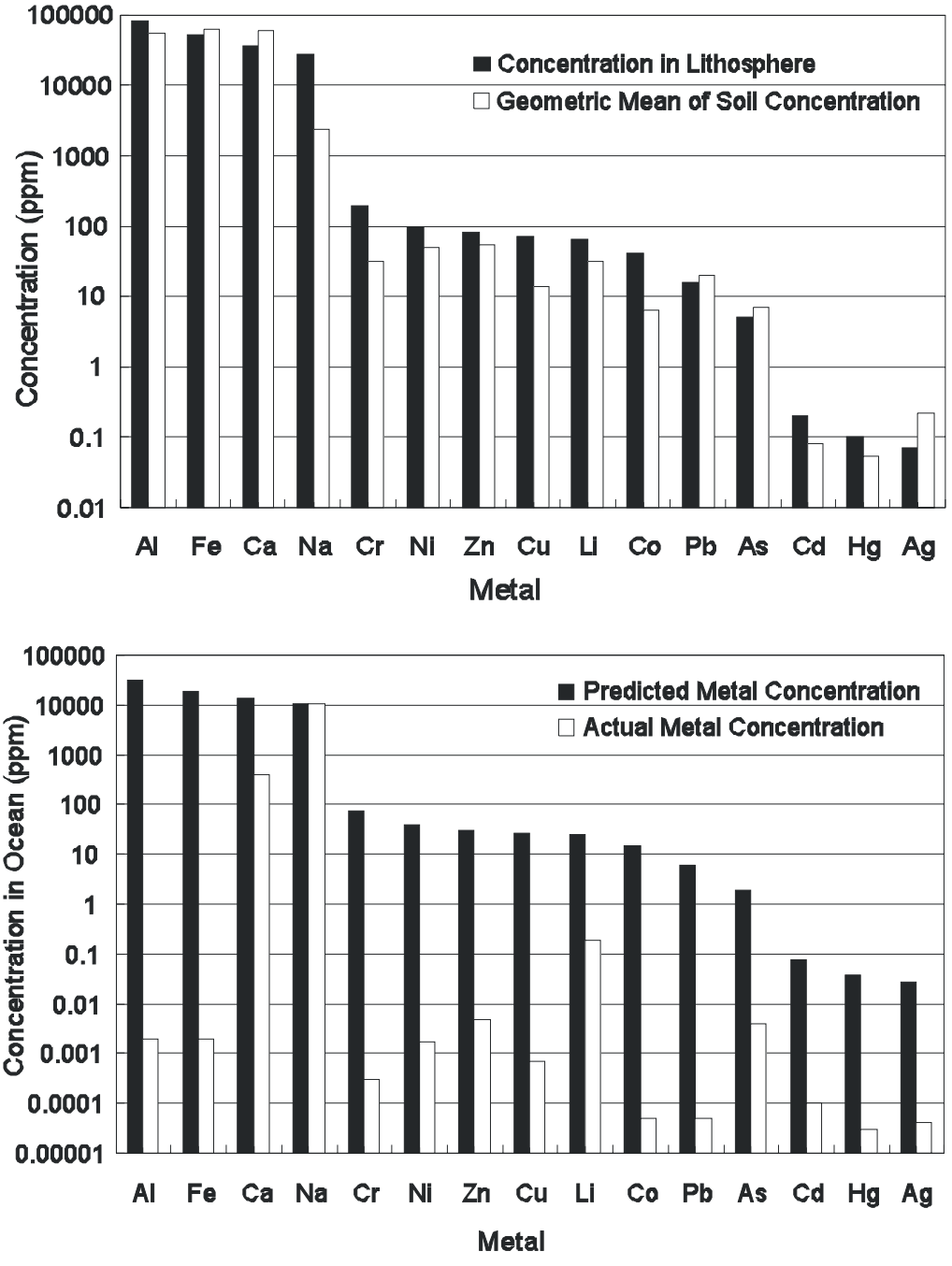


Figure 14. Screening Analysis for Persistence of Metals in Oceanic Waters

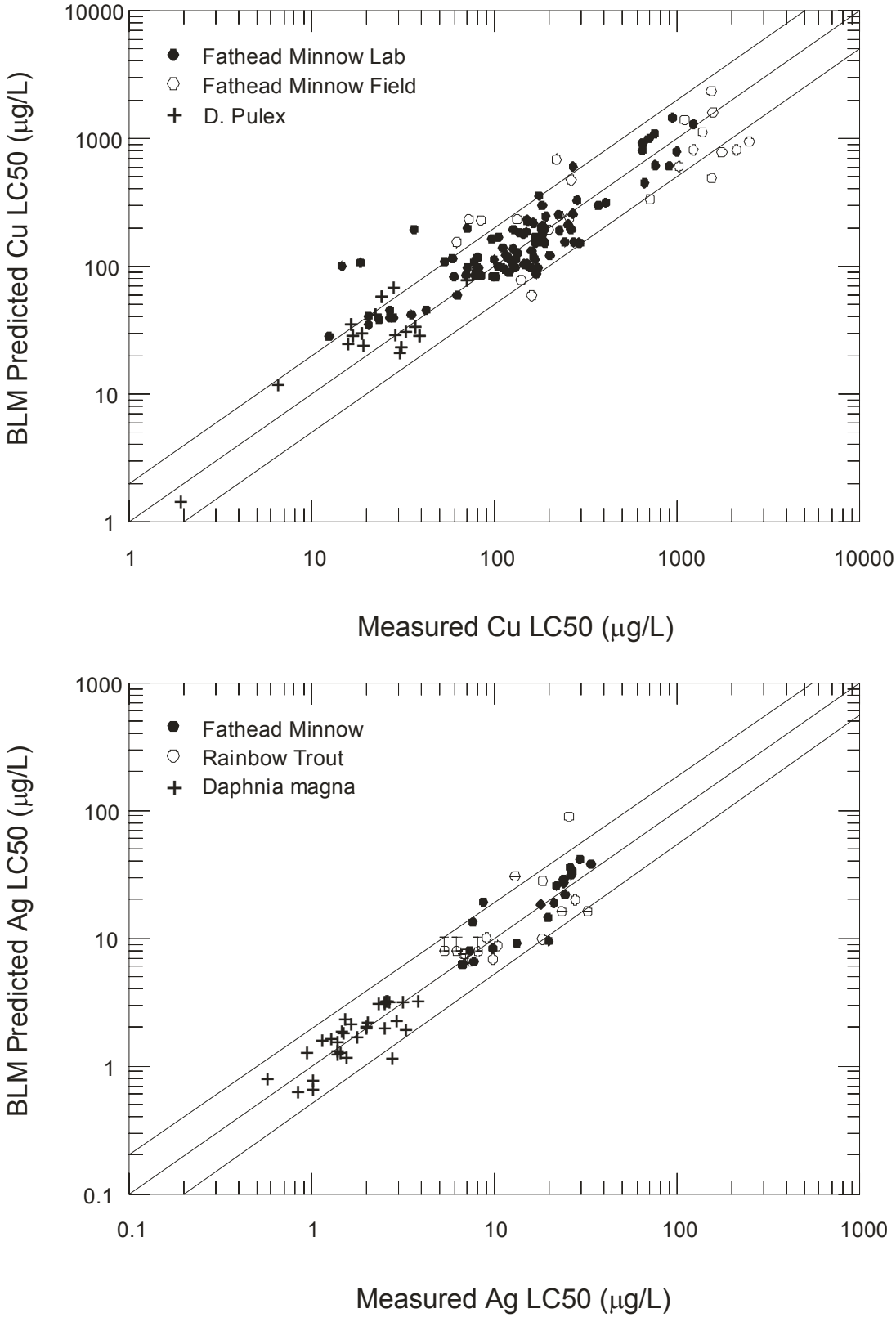
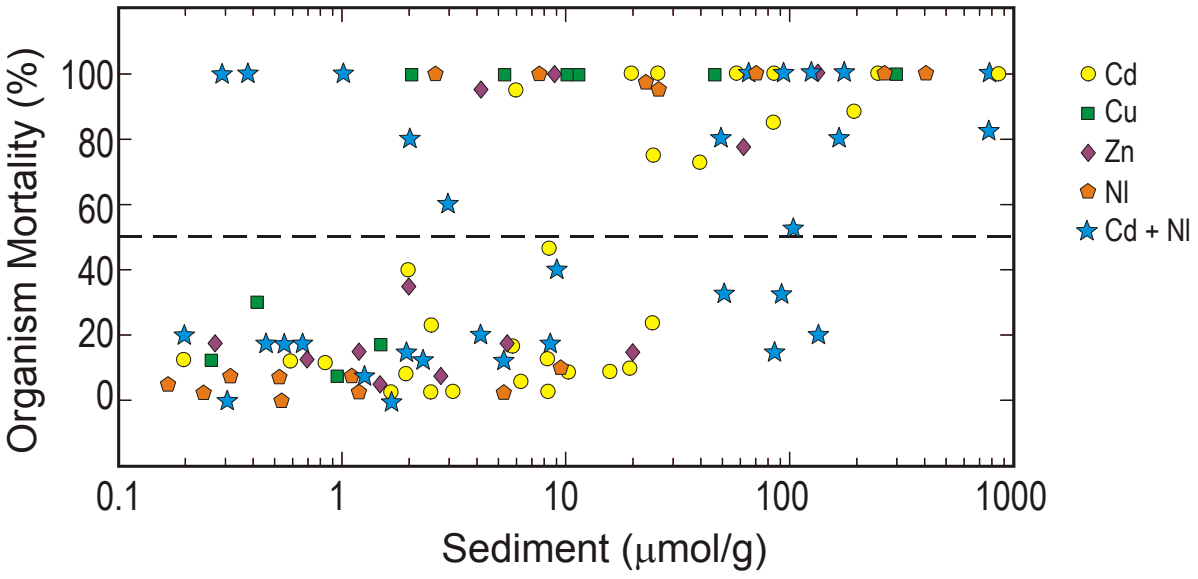


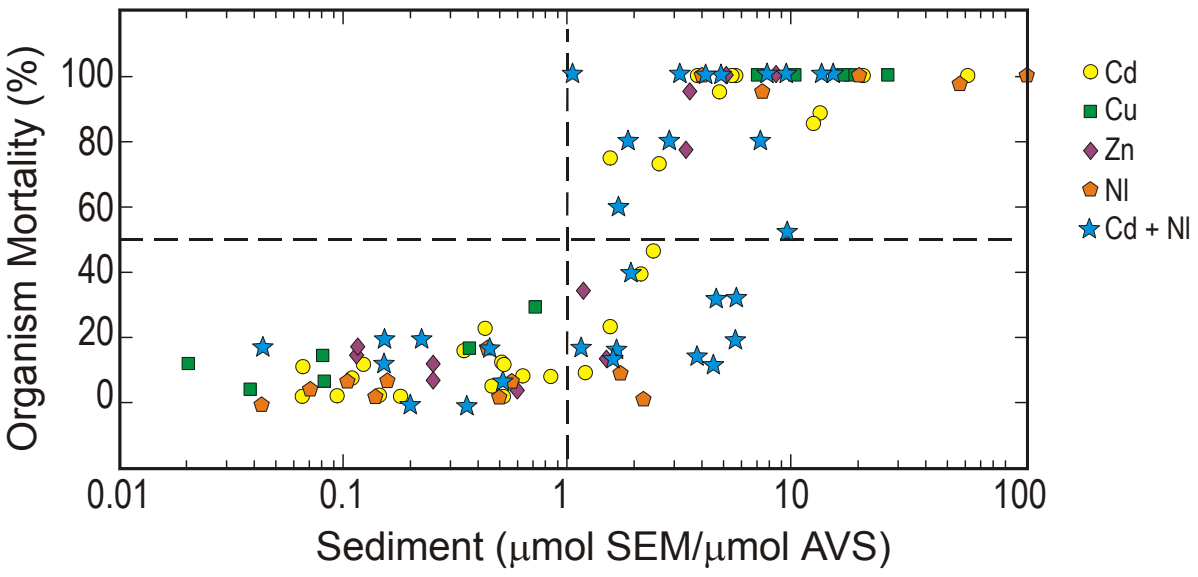
Figure 26. Demonstration of Predictive Capabilities of BLM Predicted LC50 Versus Observed LC50 for Copper and Silver

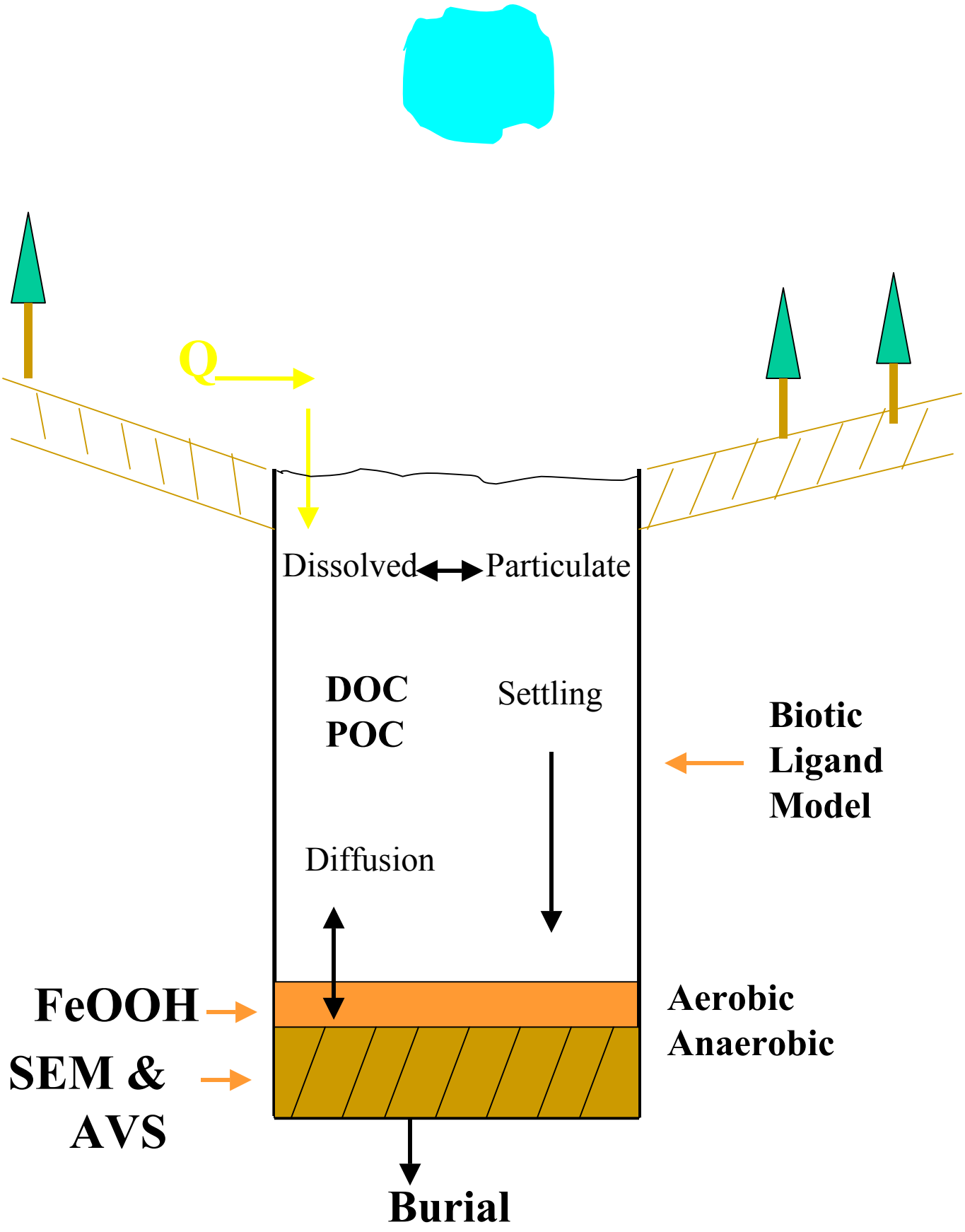
ACUTE TOXICITY OF METALS TO AMPHIPODS

DRY WEIGHT NORMALIZATION



ACID VOLATILE SULFIDE NORMALIZATION




Q
Dissolved
Particulate
DOC
POC
Settling
Biotic
Ligand
Model
Diffusion
FeOOH
SEM &
AVS
Aerobic
Anaerobic
Burial

Conclusions and Recommendations:

- The biologically available forms of metals are not persistent in aquatic systems.
- Failure to consider metal fate and availability will introduce significant uncertainty and bias in an LCIA for metals and metal compounds.
- A Unit World Model for Metals should facilitate consideration of these factors in an LCIA.
- This conceptual idea of a Unit World Model is applicable to both OC's and metals.
- Methods for integrating results across impact categories, for developing a ranking system, and for making cross-product comparisons require further development.