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Biotic Ligand Models for Metals—A Practical Application in the Revision of Water Quality Standards in China

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The current water quality standards (WQS) in China were issued in 2002. [1] According to the surface water environmental function classification and protection target, all surface waters are divided into five classes. Class I waters generally have the most stringent WQS and Class V the least stringent. The WQS have played an important role in China. However, they need to be updated to better reflect the latest advances in research, and regional water quality characteristics of Chinese waters.

Chinese regulators are planning to begin revisions to the national WQS by the end of year 2012. Because there is currently no scientific research being directed at the development of water quality criteria (WQC) or WQS that are specific to China, a common approach is to build upon the successful WQC experiences of other countries. [2] To some extent, current WQS for some chemicals might under-protect or overprotect freshwater aquatic species. [3] The reason is that many WQS fail to consider how site-specific water chemistry influences the bioavailability and toxicity of chemicals to aquatic life. So, it is imperative to carry out WQC research to support the updating of WQS in China. A bioavailability-based method should be used to harmonize the approach for setting WQS for metals in China with the current understanding of how water quality influences the effects of metals on aquatic organisms.

Efforts to incorporate the influence of water chemistry on metal bioavailability into the derivation of updated WQC are ongoing throughout the world. One approach for doing so is to use the biotic ligand model (BLM). The BLM allows metal–organism interactions to be taken into account and, given site-specific information on water chemistry, to evaluate the dissolved metal concentration associated with a critical level of metal accumulation that is toxic to an organism. The BLM serves as a powerful tool for predicting metal toxicity because it accounts for the concurrent influences of several environmental factors that alter site-specific metal bioavailability to an organism.

The influence of water chemistry on metal bioavailability and effects has been reflected in updated regulations in several countries. For example, the U.S. Environmental Protection Agency (EPA) has already adopted a BLM-based WQC for copper. [4] The copper-BLM has been applied to several organisms at different trophic levels. Incorporation of the copper-BLM into EPA's copper-WQC is based on an acute toxicity BLM. The European Union (EU) has launched a European Union Water Framework Directive. WQC for copper and other metals that have been developed for use within this regulatory framework are typically based on site-specific effect levels that are evaluated by means of chronic BLMs. To date, the BLM has not been widely used in WQC research in China, and only a few studies have attempted to use BLMs to predict metal toxicity in surface waters.[5] Therefore, it is necessary for Chinese scientists to begin to apply currently available BLMs for metals to Chinese waters and to conduct the research that will be needed to implement updated WQC for metals, especially for nickel, copper and zinc, over concentration ranges that reflect water quality characteristics of Chinese waters.

There are several reasons why it will be a great challenge to apply BLMs to Chinese waters. First, the physicochemical properties of Chinese surface waters are somewhat unique. As one example, eutrophication is a serious problem in some inland lakes and rivers, such as Lake Taihu, which means concentrations of dissolved organic carbon (DOC) and other parameters will likely be elevated. There are also other regional differences in water chemistry (e.g., pH and hardness), and these geochemical boundaries need to be considered when using the BLM as well. Given the relatively "clean", less eutrophic characteristics of EU and U.S. freshwaters, it must be determined if BLM parameter values evaluated for concentration ranges of environmental constituents in those settings

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will be appropriate for use in Chinese waters. Another reason why it will be a challenge to apply BLMs to Chinese waters is that the sensitivity of native species to metals in China may differ somewhat relative to other countries. Although the BLM has been successfully applied in the EU and U.S., it is not certain whether the parameters evaluated on the basis of tests with species from U.S. and EU waters will be applicable to Chinese waters. The applicability of current BLMs to China will be determined by performing toxicity tests with several native Chinese species to calibrate the models.

The Chinese government has recognized that updated environmental standards are needed to achieve environmental protection of Chinese waters. Such standards must reflect regional water quality characteristics and the latest advances in science and technology. China is endeavoring to develop WQC systems, but has not initiated comprehensive research on WQC systems so far. There is an urgent need to develop WQC systems suitable for the regional characteristics of China by learning from proven international practices. Based on the ideas mentioned above, and in view of the status of WQC research in China, it will be important to take into consideration the BLM in the derivation of updated WQC for specific metals (e.g., nickel, copper, and zinc). The BLM will provide a technically defensible and appropriate scientific basis for revising WQS for metals in China. However, considering the need for validation of current BLMs for use in Chinese waters, their actual implementation will not occur in the immediate future. China recently established the *State Key Laboratory for Environmental Criteria and Risk Assessment*, and several major projects supported by the Ministry of Environmental Protection and the Ministry of Science and Technology, to establish a national WQC system, are also under way. Use of the BLM should be incorporated into these efforts.

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Notes

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