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Refocusing on Nonpriority Toxic Metals in the Aquatic Environment in China

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Copper (Cu) and zinc (Zn) are nutritionally essential elements and as such, their potencies to cause toxic effects on humans and freshwater organisms are relatively less in comparison to other more potent nonessential metals. However, results of recent studies have suggested that Cu and Zn in waters[1,2] and sediments[3,4] can be more hazardous to freshwater organisms than those of Cr, Pb, or Cd in typical lakes in China (Figrue 1). For instance, in Tai Lake in southeastern China, the ecological risk ranking of various metals in water was: Cu > Zn > Cr ≥ Ni > Pb > Cd > As > Hg[2]. In fact, other countries such as the United Kingdom[5] and The Netherlands,[6] have also reported greater risks of Cu and Zn to aquatic organisms in surface water, relative to other metals. Risks posed by Cu and Zn in typical lakes and rivers motivated us to refocus on such nonpriority toxic metals for their ecological risks and regulatory actions in the aquatic environments.

Reported risks of Cu and Zn in typical aquatic environments of China have resulted from increasing environmental exposure relative to thresholds for effects of for some aquatic organisms. During the past 20 years, annual production of Cu and Zn in China and the rest of the world has ranked in the top three compared to other metals such as Pb, Cd, Cr, Ni, As and Hg. In addition, a large proportion of the metals produced in China was also consumed domestically. As a result, due to discharges of industrial wastes, mine tailings/landfill leachate and atmospheric deposition from industrial manufacturers and metal mining/smelters etc., in China, increasing concentrations of Cu and Zn have been observed in aquatic environments. For instance, in Tai Lake, concentrations of Cu and Zn in water, sediments and some organisms were greater than those of Cr, Pb, or Cd. On the other hand, aquatic organisms are generally more sensitive to Cu and Zn in water than are humans. Fish and crustaceans are 10- to 100-fold more sensitive to Cu than are mammals. This is generally interpreted as being due to the mammalian liver and kidney being part of a generally more mature detoxification system than other organisms.[7] Furthermore, Cu and Zn are nutritionally essential elements, concentrations of which are homeostatically regulated in tissues and thus their toxic effects on humans are relatively less in comparison to other more potent nonessential metals. However, because some sensitive aquatic organisms such as fishes have external gills they are, in general, more sensitive to Cu and Zn in water than are humans.

Since differences in potencies of Cu and Zn between humans and aquatic organisms are as much as several orders of magnitude, some countries have enacted more stringent standards to protect aquatic organisms from effects of Cu and Zn than for protection of health of humans from exposure via drinking water. Chronic water quality reference values of Cu and Zn provided by U.S. Environmental Protection Agency (1984, 2009) for protection of freshwater aquatic life are 9 mg Cu/L and 120 mg Zn/L, which are significantly less than that for protection of human health (1300 mg Cu/L and 7400 mg Zn/L). Although China also developed stringent standards for concentrations of Cu and Zn in water (10 and 100 mg/L, for Cu and Zn, respectively) in order to protect of fisheries, such fishery standards were implemented only in approval delineated single fishery waters. These large lakes with integrated

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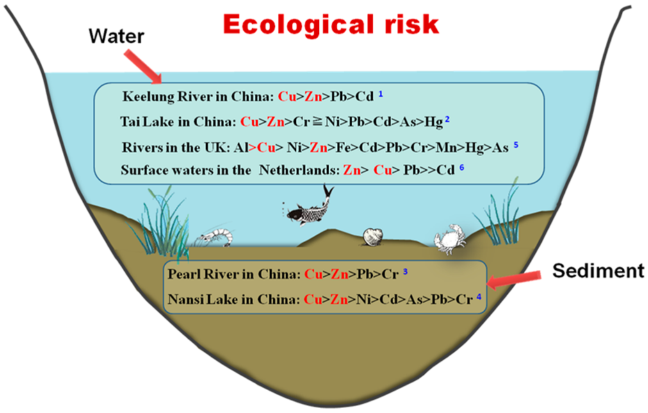

Figure 1. Ecological risk ranking of metals in typical aquatic environments in China and other countries.

ecological function such as Tai Lake are beyond the scope of fishery waters. As a result, controlling limits of metals have not yet been implemented in all lakes as part of Chinese water quality standard for fisheries. Quality criteria in water of lakes were generally implemented according to grade II and III standards of Chinese Surface Water Quality Standards (1000 mg/L for both Cu and Zn).[8] This management strategy is adequate for protection of human health, but would not be considered sufficiently protective to guarantee safety of concentrations of Cu and Zn for aquatic species.

China had suggested four metals including Pb, Cd, Cr, Hg, and a metalloid (As) as the highest priority pollutants for control in the "12th five-year plan for comprehensive prevention and control of heavy metal pollution" in 2009. By the end of 2015, the total emissions of the five highest priority metals decreased by 27.7% compared with 2007 (http://www.gov.cn/xinwen/2016-11/30/content_5140517.htm). Cu and Zn were not listed as the highest priority pollutants. Studies are needed to determine whether dose−response relationships and synergistic effects of multiple metal contaminants established for Cu and Zn for aquatic organisms is valid in those typical lakes and rivers of China and other countries, which might provide a stronger basis for future policy evaluation. More stringent standards or more strict implement for emissions of wastewater and wastegas from industrial manufacturers and metal mining/smelters etc. might ultimately be needed to reduce ecological risks posed by Cu and Zn in aquatic environments. More stringent standards will require that more funds be invested to upgrade production processes and pollutant treatment facilities. Environmental regulators, however, may be challenged by industry or business associations when they try to implement new laws/standards.

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Notes

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