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Estuarine Pollution of Metals in China: Science and Mitigation

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SCIENTIFIC OPINION
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Interactions between humans and estuaries are intimate since much of the contemporary human activity occurs in the coastal zone. Estuaries provide much of the seafood and are the intensive sites for aquaculture. While this was often the case in the past, estuaries in China are now under severe environmental threat following several decades of rapid economic development. In recent years, many estuaries have been both directly or indirectly receiving effluents generated from the industrial activities. These industrial along with domestic waste effluents have now affected the estuarine ecosystems in an unprecedented manner in human history in China. Many villages that were once sustained by "fish and rice" have abandoned farm practices because of the very recent contamination. In this viewpoint, we would like to highlight that estuarine metal pollution in China is both a persistent and emerging environmental problem. We argue that there are numerous scientific questions surrounding the complexity of estuarine physical and geochemical environments and the organisms that inhabit them. The discovery of the "colored" oysters in some of the Chinese estuaries demands attention and major efforts to study the impacts of metal pollution on estuarine ecosystems. Some of these contaminated sites provide a natural laboratory to examine the interactions between contaminants and the coastal food web. Studies that identify the key processes and provide the science necessary to underpin effective guidelines are indispensable. In one estuary in Southern China, the blue and green colored oysters were first discovered in 2010.[1] These colored oysters were severely contaminated with metals such as Cu, Zn, Ni, and Cr. Such vivid blue and green oysters have since been discovered in other estuaries. In a few occasions, Cu and Zn concentrations in oyster tissues were as high as 7.4% of its tissue dry weight.[2] In a recent field trip (July 2014) in Southern China, deep blue oysters were still widespread, and there is no evidence that the pollution has been reduced as compared to 4 years ago when these colored oysters were first discovered. Highly acidic, metal-rich waters are discharged regularly to the estuary, with little if any mitigation. Similar threats are emerging elsewhere and the impacts are expected to persist. These blue oysters (Figure 1) are evidence of the need for a stricter control of effluent releases and a cry for a national focus on metal pollution in estuaries in China.

Figure 1. Blue color oyster collected from an estuary in Southern China.

Major scientific questions remain as to how these organisms survive under such severe environmental stress. For the oysters which are considered hyper-accumulators of metals, questions are why they can accumulate such high metal concentrations,

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why they do survive in such extraordinary contaminated environments, and how they handle metals in their bodies. What will be the implications for human health since oysters are a favorite seafood? Recent studies indicate that oysters may be able to reduce their uptake of metals or detoxify the metals via metallothioneins.[1,3] A much bigger issue is for the estuarine ecosystem that hosts species with widely varying behaviors and metal exposure pathways. Sediment quality guidelines should consider all exposure routes and the influence of sediment properties on metal bioavailability and toxicity.[4] In addition, the impact of estuary pollution on local ecosystem function and food web structure deserves greater consideration. How increases in concentrations of both metals and major nutrients such as C, N, and P influence species diversity, abundance and community structure, and the biogeochemical cycling of these elements, remain largely unknown. Very few studies have investigated how tidal mixing affects the partitioning of metals among dissolved, colloidal and particulate phases, and concurrently evaluated how these processes influence metal accumulation and effects on organisms that inhabit this dynamic environment.

Estuaries are drastically different from coastal waters, having extreme gradients in hydrographic and geochemical conditions. Both continuous release and intermittent contaminant releases are common. Industrial effluents are often stored in holding ponds and, once the water level reaches a certain height, they are released during the low tide. Ecotoxicologists need to consider the complicated local hydrodynamic and geochemical environments following effluent discharge. Such dynamic field conditions present great challenges for scientists who seek to develop models to accurately predict the exposure and potential toxicity of effluents. One further complication is the issue of metal mixtures, in both dissolved and particulate forms. Much remains to be studied regarding metals' synergistic effects on their bioaccumulation (bioavailability) and toxicity. One excellent example is that the Cd concentration in some of the southern estuaries in China is not abnormally high in the water (<0.1 μg/L), yet the Cd concentrations in the oysters can easily exceed the food safety standards (e.g., 2 mg/kg wet weight). Recent studies have shown that the high Cd concentration in the oysters likely resulted from the high Zn concentrations in the estuarine waters,[5] whereby the presence of high Zn facilitates Cd uptake. This metal mixture interaction has been greatly ignored, and more studies are needed both in terms of fundamental processes and modeling.

What will be the mitigation measures for such estuarine pollution and the sustainable way of moving forward? Obviously, the most effective measures, as often argued by some Chinese scientists, are to stop the releases of these polluted waters and to remove the contaminants before the effluents are released. Both measures are however costly for the government and the industrial sectors. Just recently, the government announced that it may spend 2000 billion RMB (close to $US340 billion) on water pollution prevention, which is in the final stage of approval by the State Council. Much of the money will probably be channeled to technology development to recycle the metals and other environmental pollutants. Better coordination between the environmental protection departments and the water authorities as well as law enforcement on the controls of these industrial and domestic effluents needs to be achieved. Regular monitoring to identify the sources and scales of effluent releases and to establish maximum daily load limits is strongly recommended. Simple report cards and education sheets to outline the principals behind any guidelines, monitoring and consequences to the environment may be effective. Finally, the best current guidelines from around the world need to be incorporated, with an aim to keep the guidelines simple and effective, but to avoid some of the 'mistakes' from elsewhere.

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Notes

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