Novel scientific method to derive water quality criteria of metals for protecting different marine ecosystems worldwide

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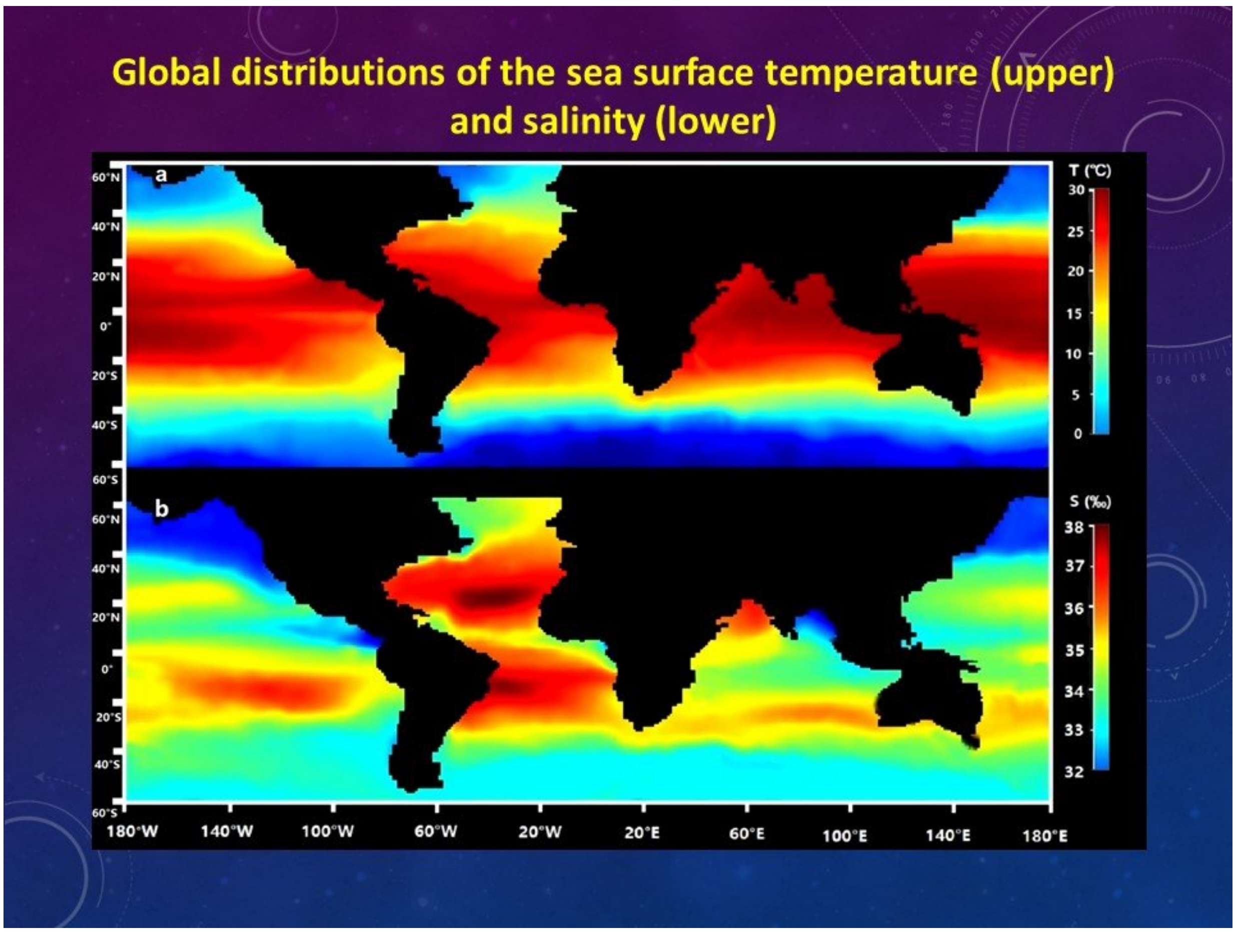

Global distributions of the sea surface temperature and salinity, which vary among different geographical regions. Credit: The University of Hong Kong

Increasing contamination of marine ecosystems by metals such as mercury, cadmium, chromium and nickel is a global environmental concern, because elevated concentrations of metals can pose hazards to marine organisms, and humans who may consume contaminated seafood. Setting water quality criteria (WQC) for metals (i.e., environmental safety limits) is an essential step for assessing and regulating risk levels in the marine environment, and hence offering protection to marine organisms and ecosystem integrity.

At present, the current method for deriving WQC of metals in Australia, Europe and North America is primarily based on laboratory data generated by conducting toxicity tests with marine organisms in fixed laboratory conditions (e.g., a fixed combination of temperature and salinity). Such laboratory-derived WQC may not be protective to marine ecosystems because environmental conditions in the natural environment are often very different from those of the laboratory setting. In reality, the environmental conditions vary among different geographic regions (e.g. tropics vs. temperate regions); even in the same region, environmental conditions such as water temperature and salinity change seasonally. Such changes can substantially influence the toxicities of metals to marine organisms.

Over the past decade, environmental scientists have been looking for a way to predict the toxicities of metals and derive their WQC for protecting the biodiversity and integrity of marine ecosystems with different environmental conditions. This task is tremendously important to environmental protection.

Professor Kenneth Leung, Deputy Director of School of Biological Sciences and Scientist of the Swire Institute of Marine Science of HKU and international collaborators jointly tackled this global issue. The team spent three years developing a novel empirical model for estimating the toxicities and deriving WQC for metals and metalloids in coastal marine environments with variable temperature and salinity regimes. Their method is based on an integration of temperature- and salinity-based species sensitivity distributions (SSDs) with quantitative ion characteristic relationships (QICAR) model, while parts of their model results are validated with empirical data. The team also analysed real-time environmental data of sea surface temperature and salinity in different parts of the world and applied their model to derive provisional site-specific WQC for more than 30 metals and metalloids.

The research team made use of big data and developed the novel model for predicting metal toxicities and deriving their site-specific WQC in marine environments worldwide. This important innovation has been published in the latest issue of the international journal *Environmental Science & Technology*.

The results indicate that metal toxicities to marine organisms generally increase with increasing seawater temperature, but the metal toxicities are found to be the lowest at an optimum salinity and increase when the salinity increases or decreases from the optimum salinity. If a WQC of a metal is derived from a laboratory experiment conducted at optimum temperature and salinity, such a WQC is unlikely to be protective to marine organisms living in an environment with higher temperature and lower salinity.

The results also suggest that marine species living in warmer waters in the tropical region (including Hong Kong and South China) are more susceptible to metal toxicities than their temperate counterparts. Many governments in Asia such as Hong Kong and Korea often employ temperate toxicity data for deriving WQC or directly adopt the WQC generated from Europe and North America, but such surrogate uses of temperate information for protecting tropical marine ecosystems pose high uncertainty in the margin of safety.

The novel method developed by the team will greatly improve the management of metal and metalloids in coastal marine environments worldwide, as environmental authorities can employ this method to derive provisional site-specific WQC for facilitating better ecosystem protection with consideration of specific environmental conditions and potential influences of global climate change.

Professor Wu Fengchang said: "Professor Kenneth Leung and his team at HKU have already revealed the temperature- and salinity-dependent toxicity profiles of various pollutants and produced the relevant empirical datasets, while our team at CRAES is good at quantitative structure-activity relationship modelling for metal toxicities. Our complementary knowledge and skills are prerequisite of the success of this collaborative project. We are very delighted to work together."

Professor Wu also views that the results of this study will be of enormous benefit in deriving WQC of metals for different parts of marine environments in China and beyond.

Professor Kenneth Leung said: "In Hong Kong, salinity in the western marine waters is relatively low due to freshwater discharge from the Pearl River, whereas the salinity in the eastern waters is consistently high because of dominant influence of oceanic currents from Pacific Ocean and South China Sea. With consideration of such salinity differences, the method developed by the team can be readily applied to derive provisional site-specific WQC of metals for enabling better protection to the eastern and western marine ecosystems of Hong Kong, respectively."

"Our new method not only enables different countries to derive site-specific WQC of metals for safeguarding their marine environments, it will also bring socioeconomic benefits to societies around the world. It is because we can reduce the number of toxicity tests, use less chemicals in the tests, kill fewer animals, and greatly save money and time for conducting such tests." Professor Leung added.

The research team will further investigate the influence of dissolved and suspended organic matter on toxicities of metals in seawater, with a view to improving their model. They will also make use of field-based monitoring data of metal concentrations and marine biodiversity to validate their derived provisional WQC in different water bodies.

More information: Yunsong Mu et al. Model for Predicting Toxicities of Metals and Metalloids in Coastal Marine Environments Worldwide, *Environmental Science & Technology* (2018). DOI: 10.1021/acs.est.7b06654

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