Developing Risk Assessment Methods for Chemicals in Sediment That Consider Exposure Routes and Bioavailability to Benthic Organisms

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[Abstract]

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In chemical regulations, sediment risk assessment is required for substances that accumulate in the sediment of aquatic environments. However, the exposure of benthic organisms to chemicals is complex, leaving various technical issues unresolved. The objective of this project was to establish comprehensive risk assessment methods that consider different routes of exposure and the bioavailability of chemicals. To this end, research was conducted under three Sub-themes: (1) Assessment of chemical toxicity to benthic organisms by sediment-water exposure tests; (2) evaluation of distribution behavior and bioavailability of chemicals in sediments; and (3) optimization of the equilibrium partition method (EPM) and development of comprehensive sediment risk assessment methods.

In Sub-theme 1, new toxicity data of 10 chemicals were generated for fresh water (*Hyalella azteca*) and brackish water (*Grandidierella japonica*) amphipods by spiked-sediment toxicity tests. By measuring total dissolved (C_{diss}) and freely dissolved (C_{free}) concentrations, direct comparison to water-only tests was possible. The results indicated that C_{free} in porewater is generally useful for explaining the toxicity under different exposure conditions, while overlying water may also contribute to the toxicity to *G. japonica*.

In Sub-theme 2, passive sampling methods using polymer-coated fibers were established to measure C_{free} in the sediment toxicity test system. Measuring C_{diss} and C_{free} demonstrated spatial and temporal variability of these concentrations, suggesting non-uniform exposure conditions. A mass transfer model was used to gain mechanistic understanding of the observed chemical distributions. Sorption tests with environmental sediments showed that the fraction of organic carbon (f_{oc}) can normalize the sorption properties of differing sediments for neutral hydrophobic chemicals.

In Sub-theme 3, 142 chemicals were screened for their potential risks in sediments by the EPM, of which 58 were identified as requiring more detailed assessment. Comparison of the results from the EPM and sediment toxicity tests indicated that toxicity estimation by the EPM can be improved by adopting toxicity data, f_{oc} and sorption coefficients more suitable for sediment risk assessment. Our recommendations for improved sediment risk assessment include the following: Exposure concentrations should be measured in sediment toxicity tests, preferably at locations relevant to the test species; C_{free} in porewater is a useful exposure metric, although other phases can also be relevant; the EPM with adjusted parameters can be used for screening purposes, while C_{free} measurements in toxicity testing and field monitoring can be considered for higher-tier assessments. Finally, a tiered approach for sediment risk assessment was proposed based on the results from the project.

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