

Applying chemical activity in environmental geochemistry: Advancing biological effect assessment of hydrophobic organic contaminants in sediments

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Understanding the biological effects of hydrophobic organic contaminants (HOCs) in sediments is essential for environmental risk assessment and ecosystem management. Traditional monitoring frameworks rely on concentration-based assessments of individual contaminants, which often fail to capture the cumulative and interactive effects of complex mixtures. This limitation hampers our ability to accurately link chemical exposure to biological effects, leading to gaps in environmental assessment and regulatory decision-making.

Chemical activity is emerging as a powerful metric that integrates mixture toxicity potential by expressing contaminant levels in terms of their thermodynamic potential to exert toxicity. Unlike conventional concentration-based approaches, chemical activity provides a biologically relevant measure that accounts for the bioavailability and toxic pressure of HOCs. Combined with biological effect indicators and complementary metrics such as pollution load indices for metals, this approach significantly enhances our ability to detect contaminant-induced ecological impacts.

Recent advancements in effect-based monitoring have demonstrated the value of chemical activity for improving the accuracy of environmental status assessments. By incorporating this metric into regulatory frameworks, we can link chemical and biological aspects of the contaminant assessment and thresholds for Good Environmental Status (GES) under frameworks, such as the Marine Strategy Framework Directive (MSFD), and develop more effective diagnostic tools for evaluating pollution impacts across different marine and freshwater ecosystems. We can advance risk assessment methodologies and support more effective environmental protection policies worldwide by bridging the gap between chemical exposure and ecological impact.