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Site-Specific Sediment Criteria: A framework for using bioassays as a tool for risk assessments

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Abstract

As part of the risk assessment framework, sediment constituent loads are often compared to common, but loosely relevant, benchmark levels as part of determining the potential for an impact to biological life. There are several technical and regulatory scenarios that benefit from the development of site-specific sediment criteria, including constituent- or condition-specific information gaps or the lack of observed biological response in previous monitoring. Bioassays have the ability to serve as a powerful, integrated tool to support a decision maker's weight-of-evidence approach. The participation of scientists with expertise in bioassay methods and their proper adaptation and interpretation are invaluable to a risk assessment team as they develop goals and plan sampling and analysis design. Site-specific criteria can be calculated using sediment amendment (i.e., spiking studies) and subsequent biological evaluation to more fully characterize local conditions as well as the viability of potential remediation alternatives. When undertaking these studies, multiple factors critical to understanding the design should be considered during planning stages, well before execution of any field work. This presentation aims to provide context, applications, and considerations for bioassay testing as it relates to risk assessment beyond a typical monitoring regime.

When can bioassays be a useful tool? Consider applying when…

- Site clean-up, mitigation or other processes are being delayed due to chemical measurements exceeding published benchmarks
- There are no published benchmarks for a given constituent that is being identified as a potential concern (current example would be PFAS)
- Published data are available for the constituent of concern, but data are not relevant to site conditions or available for species of concern
- Data comparisons or modeling have gaps that lead to drawing overly conservative conclusions in the absence of data
- There is a question of partitioning or bioavailability of the constituent of concern
- Toxicity has been observed and multiple constituents are above threshold levels; determination of primary driver(s) and relative contributions or concentrations can guide remediation and clean-up efforts
- Determination of clean up levels would be better supported
- Assignation of responsibility to PRPs would benefit from direct measurements

Critical questions and considerations prior to engaging in a study

- Clear definition of study goals: clear goals -> good project design -> no data gaps -> acceptance of conclusions by all stakeholders
- Does the regulatory framework exist to apply site-specific criteria? Can we make a compelling case for why these data are useful in improving decision making?
- Are the proper stakeholders and experts involved? Improve client and regulatory understanding and concurrence; engage risk assessors, toxicologists, and chemists, ensure clear public communication.
- Is the design sufficiently comprehensive to ensure no data gaps will hinder interpretation or add uncertainty? Strike the balance between an iterative, targeted approach vs. overcomplicating design and creating cost burdens
- Is the cost benefit analysis in line- does the potential cost of not doing the testing outweigh the effort of the study; is this the most cost effective tool ?

Case Study: Spiked Sediment Risk Assessment

Background

- Barium identified as a constituent of concern in bulk sediment analysis- present above regional regulatory screening levels, limited bioassay data for barium in freshwater sediments

Key Consideration- site specific design to answer a meaningful question

Study Design

- Thorough Site Assessment - Quantify levels and speciation of constituent, key parameters for both sediment and overlying water
- Known form of barium (barium sulfate) in products used on site
- Species selection based on state specific sediment guidance combined with relevance of exposure scenario
- Selection of media for amendment - lab control sediment vs. reference sediment; which better helps answer the question?
- Goal is to minimize confounding factors while maximizing similarity of target site conditions

Key Consideration- understanding how sediment and water quality criteria may affect target constituent (organic carbon, grainsize, sulfides, microfauna; DOC, pH, alkalinity, hardness)

Methods

- 20-day solid phase *Chironomus* method
  - Conservative chronic endpoint- sensitive life stage, resides in sediment (more appropriate exposure pathway for constituent of concern)
  - Concurrent reference toxicant testing
- Sediment amendment
  - Concentrations spiked at 100% above target to account for potential loss
  - Reference sediment combined with custom laboratory water amended with barium sulfate
  - Mixed under and allowed to equilibrate under a nitrogen atmosphere
  - Subsamples analyzed for measured values
  - Reference blank tested for comparison

Key Consideration- spiking concentrations, amendment technique, equilibration time

Results

- No statistically significant effects observed in any spiked barium test concentrations
- Chronic NOEC barium sulfate in freshwater sediment >1,580 mg/kg
- Mortality and growth endpoints for the *Chironomus* midge

Sample ID and Nominal Barium Concentration (Measured Barium; mg/Kg)	Mean Survival (%)	Mean Growth AFDW per Surviving Organism (mg)
Lab Control (14.2)	83.3	0.22
REF2 Blank (68)	83.3	0.56
REF2 81 (155)	90.0	0.69
REF2 163 (289)	91.7	0.59
REF2 325 (513)	86.7	0.57
REF2 650 (1,010)	83.3	0.39
REF2 1300 (1,540)	81.7	0.57

Lessons Learned

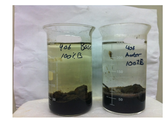
- Importance of having a reference for comparison of results
- Importance of weighing the costs of bioassays program against clean up
- Communication with laboratory vital to success of bioassay program

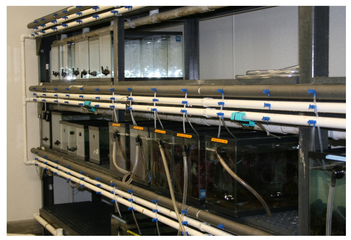
Technical Considerations

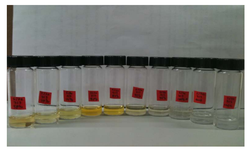
- Exposure design in site-specific context of regulatory goals, guidelines, and questions, e.g., acute vs. chronic vs. bioaccumulation
- Species selection considerations should include matrix, partitioning, relevance for ambient/ receiving environment, regional guidance for testing programs, sensitivity, exposure pathway
- Recognize when method modifications might be appropriate given the study goals
- Inclusion of appropriate reference materials where needed- specifically when undertaking a spiking study or targeted site assessment
- Full understanding of how various chemical parameters (pH, hardness, grainsize) can influence the constituent of concern- control for as many as possible and fully document details for later interpretational context
- Ability to separate, parse, and assign contributory values when multiple constituents are involved
  - Tracking toxicity throughout the phases of the study
- Positive and negative controls- clarity about what you can and can't account or control for; What will serve as the basis of comparison for results? What best serves solid decision making?
- Understanding of data applicability- How will the results be used? How best communicated clearly? Consider statistical robustness resulting from test design decisions

Additional Conclusions

- Take a fresh look at sites that might benefit from a new approach, particularly where uncertainty or technical disagreement is delaying action or closure
- Begin to plan well in advance of target delivery- rushing these studies can lead to lack of acceptance based on data gaps or unanswered concerns
- Communication is vital to the success of the program- use an experienced lab with deep technical understanding and bring them in early for the study design and planning







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