Diel Metal Cycles: Toxicity Considerations

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Overview

In relation to diel metal cycles:

- Has the toxicity of fluctuating concentrations been accounted for in water-quality criteria?

- Are water-quality criteria and practical monitoring strategies properly linked?
Standard Acute Toxicity Testing

- Typically, 96-hour bioassay in laboratory with survival as endpoint
- Tests at different (but constant) concentration

Dose-Response Curve
Experimental Question

Which is more toxic?

- Constant metal concentration
- Fluctuating metal concentration (with mean equal to the constant concentration)
Previous Studies

- Pulse events
  - Some recent studies to understand spills and episodic storm runoff

- Fluctuating concentration
  - 2 old studies:
    - Zinc: greater survival in fluctuating exposure (4-h cycles)
    - Lead: lower survival in fluctuating exposure (24-h cycles)
Field Experiments – Two Sites

(Nimick et al., 2007)
Field Experiment – High Ore Creek

Comet tailings
Water Quality – High Ore Creek

Flow-through container
Survival – High Ore Creek

The graph shows the survival rates over time for different container types:
- **Closed container**
- **Flow-through container**
- **Control**

Key points:
- **214-634 (x̄ = 428)**
- **333-750 (x̄ = 542)**
- **650**
- **612**
- **422**
- **612**

The graph indicates a higher survival rate for the closed container compared to the flow-through and control containers.
Survival – High Ore Creek

Survival significantly different ($p < 0.01$)

Closed container

Flow-through container

Control container

Survival (%)

Time (hours)

214-634 ($\bar{x} = 428$)
Survival – Dry Fork Belt Creek

Survival (percent)

Time (h)

0 2 4 6 8 10 12

Closed container

Flow-through container

Control

Survival (percent)

0 20 40 60 80 100

6-11

266-522

(\bar{x} = 399)

392

432

486

386-623

(\bar{x} = 511)

261
Survival – Dry Fork Belt Creek

Survival significantly different ($p = 0.02$)

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<th>Time (h)</th>
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<tr>
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Closed container

Flow-through container

Control

Survival ($\bar{x} = 399$)

266-522
Summary

- Results from both sites were comparable.
- Diel-fluctuating exposure appears to be less acutely toxic than constant-concentration exposure at diel mean.
- Current water-quality criteria appear to be protective for streams with diel Zn and Cd cycles for the hydrologic conditions tested.
Why Would Fluctuating Metal Concentrations Be Less Toxic?

- Coincidence of metal and temperature cycles
  - Metal uptake is slower at lower temperature
  - Less metal binds to gill at lower temperature
- Detoxification faster than accumulation at lower concentrations
Are Water-Quality Criteria and Practical Monitoring Strategies Properly Linked?

Criteria:
Acute standard:
  4-day average concentration
Chronic standard:
  1-hour average concentration

.... not to be exceeded more than once in three years
Water-Quality Criteria and Monitoring: Metals

Criteria:
Acute standard:
  4-day average concentration
Chronic standard:
  1-hour average concentration

.... not to be exceeded more than once in three years

Monitoring:
Site visits needed
Automatic samplers require attention in the field but may let you sleep
Diel variability difficult and expensive to address

Conclusion:
Criteria are out in front of monitoring. A more practical expression of criteria may be needed.
Water-Quality Criteria and Monitoring: Dissolved Oxygen

**Criteria:**
- Minimum
- 7-day average minimum
- 30-day average

**Monitoring:**
- Data sondes
- Need periodic calibration and maintenance to offset drift and fouling

**Conclusion:**
Monitoring capability has caught up with criteria
Water-Quality Criteria and Monitoring: Temperature

**Criteria:**
- Maximum daily maximum
- Maximum weekly maximum
- Maximum daily average
- Maximum weekly average

**Monitoring:**
- Hobos, Tidbits, data sondes
- Easy calibration, accurate, no drift

**Conclusion:**
Monitoring capability is out in front of criteria
Concluding Thoughts

Environmental protection is most effective when:

• Criteria are set with true variability and toxicity in mind
• Criteria are set with monitoring practicality in mind
Source of Data