Incorporating bioavailability into regulatory practice

Experiences with metals in water

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Outline

- Environmental Quality Standards - a key tool for managing water quality
- Dealing with metals - the current approach
- Dealing with metals - incorporating bioavailability
- Progress in implementing a bioavailability based approach for metals
What are EQSs?

- **Environmental Quality Standards**
- Thresholds below which we do not expect adverse effects to occur
  - Hazard-based
  - Analyse environmental samples to assess compliance (= risk)

**Classification**
- ‘Good’ status requires compliance with EQSs
- EQS exceedances trigger further investigation or remediation
- Controlling discharges to the environment
  - EQSs translated into discharge limits

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**Metal EQSs – the approach under the DSD**

<table>
<thead>
<tr>
<th>Copper</th>
<th>Hardness</th>
<th>EQS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-50mg/l CaCO₃</td>
<td>1ug/l</td>
</tr>
<tr>
<td></td>
<td>50-100mg/l CaCO₃</td>
<td>6ug/l</td>
</tr>
<tr>
<td></td>
<td>100-250mg/l CaCO₃</td>
<td>10ug/l</td>
</tr>
<tr>
<td></td>
<td>&gt;250mg/l CaCO₃</td>
<td>28ug/l</td>
</tr>
</tbody>
</table>
Bioavailability…..what is it?

- Total metal
- Total dissolved metal
- Available metal
- Bioavailable metal

Are we under- or over-estimating risk by not taking bioavailability into account?

- Under-estimate – we fail to act when we should
- Over-estimate – we waste resources

How to account for bioavailability?

- Biotic Ligand Models (BLMs)
Which metals?

Nickel

Zinc

Copper

Manganese

Bioavailable metal EQS

- Water Framework Directive requires us to develop EQSs for toxic substances
- EQSs have been derived for copper, zinc, manganese and nickel that are expressed as bioavailable concentrations
  \[ EQ_{bioavailable} \]
- EQS\(_{bioavailable}\) specifies a tolerable concentration under high bioavailability conditions
- But deriving the EQS is only half the story …
Assessing compliance with $\text{EQS}_{\text{bioavailable}}$

Assess compliance in order to
- Classify (e.g. 'good', 'poor' status)
- Identify sites for remediation
- Issue discharge permits

Estimate the bioavailable fraction at each monitoring site to compare with $\text{EQS}_{\text{bioavailable}}$

Simplified version of BLM developed
- Fewer data inputs - just dissolved [M], DOC, pH and Ca
- Easy to use
- Compatible with Agency laboratory systems

Metals Bioavailability Assessment Tool (M-BAT)

Comparing with $\text{EQS}_{\text{bioavailable}}$
- Pass: Bioavailable $[\text{M}] < \text{EQS}_{\text{bioavailable}}$
- Fail: Bioavailable $[\text{M}] > \text{EQS}_{\text{bioavailable}}$

Classify waterbodies
- Identify sites at risk from metals

Key indicators:
- pH
- $[\text{Ca}]$ (hardness)
- Dissolved organic carbon
- Dissolved metal concentration
A tiered approach to classification / investigations

<table>
<thead>
<tr>
<th>Tier</th>
<th>Classification</th>
<th>Dissolved metal</th>
<th>pH, DOC, Ca</th>
<th>Full BLM Background concentrations. Measured pH, DOC, Ca</th>
<th>Remedial measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 1</td>
<td>No further action necessary</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Remedial measures</td>
</tr>
<tr>
<td>Tier 2</td>
<td>Fail</td>
<td>M-BAT</td>
<td>Pass</td>
<td>Pass</td>
<td>Remedial measures</td>
</tr>
<tr>
<td>Tier 3</td>
<td>Fail</td>
<td>Local refinement</td>
<td>Pass</td>
<td>Pass</td>
<td>Remedial measures</td>
</tr>
<tr>
<td>Tier 4</td>
<td>Fail</td>
<td>Remedial measures</td>
<td>Pass</td>
<td>Pass</td>
<td>Remedial measures</td>
</tr>
</tbody>
</table>

1. Tier 1: Classification
   - Compare [M] in sample with EQS bioavailable
   - Tier 1: Pass
   - Tier 2: Fail
   - Tier 3: Fail
   - Tier 4: Fail

2.Tier 2: M-BAT
   - Tier 2: Pass

3. Tier 3: Local refinement
   - Tier 3: Pass

4. Tier 4: Remedial measures
   - Tier 4: Pass

Legend:
- Dissolved metal
- pH, DOC, Ca
- Full BLM Background concentrations. Measured pH, DOC, Ca
- Remedial measures
Compliance with $E_{\text{bioavailable}}^\text{EQS}$ - copper

Failure of copper EQS
current (DSD) vs bioavailability-based (BLM) approaches
Some outstanding issues

- Boundary conditions of M-BAT
- Dealing with backgrounds
- Gathering the necessary input data
- Permitting

Boundary conditions of M-BAT (copper)

pH (5.5 – 8.5)
Operating conditions of M-BAT cover virtually all UK waters

Ca (4 – 144 mg/l)
Operating conditions of copper ‘tool’ do not apply to softest 25% of UK waters (Wales, SW England, NW England)

7% of the hardest waters also not covered (Anglian, SE England)

Need to extend operating conditions of models; conservative assumptions in the interim
Backgrounds

Natural backgrounds for metals (geology + legacy of man-made releases)

- Zinc: ‘added risk’ approach - allowance for background is explicitly required when assessing compliance with EQS
- For other metals, we may want to check the contribution of backgrounds as part of investigation
- Options include:
  - National default (low %ile of monitoring data)
  - Regional default (FOREGS database)
  - Background from unimpacted reach of same catchment

Gathering the input data

- pH – routinely collected
- Ca – use monitoring data or default to hardness bandings
- DOC – commitment to collect DOC routinely but, in the interim, will need to rely on existing data or surrogates (correlation with [Fe])

How to integrate into permitting?

- Current approach sets permits expressed as total concentrations
- Site-specific permit depends on DOC, Ca, pH in receiving water – these data are not always available
- Monitoring requirements – changes in practice for both operator and regulator
### Implementing a bioavailability-based approach

<table>
<thead>
<tr>
<th>Scientific concept</th>
<th>Wide acceptance, validated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioavailability-based EQS</td>
<td>Available for Ni, Cu, Zn, Mn</td>
</tr>
<tr>
<td>Routine assessments of risk</td>
<td>M-BAT includes models for Ni, Cu, Zn, Mn</td>
</tr>
</tbody>
</table>

**Input data**
- **Dissolved [M]**: Routine
- **pH**: Routine, historical record available
- **Ca**: Estimated from hardness bands and historical data
- **DOC**: Not routine but plan to collect DOC; surrogate methods in the interim

**Boundary limits of M-BAT**
- More work needed

**Allowing for backgrounds**
- More work needed

**Regulatory roles**
- **Classification**
- **Investigation**
- **Permitting**
  - Challenges remain

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**Thank you for your attention**

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**Evolution of metals regulation**

- **DISSOLVED**
- **TOTAL**
- **BIOAVAILABLE**