Dam Removal To Restore The Assabet River

Sediment Contamination and Dam Removal (or can we do the latter while taking care of the former)

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Sources of Sediment Contaminants

- Existing and historical point sources discharges
  - Industrial discharge
  - Sewage treatment
- Atmospheric deposition of contaminants
  - Fuel combustion
  - Waste incineration
- Nonpoint source runoff
  - Harvested croplands (agricultural runoff)
  - Landfills, toxic waste storage and disposal sites
  - Urban stormwater
  - Inactive and abandoned mining sites
Q1
What standards and techniques exist to assess ecological risk of contaminants?
SQGs of note

- Fresh water TEL/PEL
- Fresh water TEC/PEC
- Salt water ERL/ERM

- Got to the NOAA Screening Quick Reference Tables – Google: NOAA SQuiRT
# Screening Quick Reference Table for Inorganics in Sediment

These tables were developed for internal use for screening purposes only; they do not represent official NOAA policy and do not constitute criteria or clean-up levels. All attempts have been made to ensure accuracy; however, NOAA is not liable for errors. Values are subject to changes as new data become available.

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Freshwater Sediment</th>
<th>Marine Sediment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&quot;Background&quot;</td>
<td></td>
</tr>
<tr>
<td>Selenium</td>
<td>290</td>
<td>1,000</td>
</tr>
<tr>
<td>Silver</td>
<td>&lt;500</td>
<td></td>
</tr>
<tr>
<td>Strontium</td>
<td>48,000</td>
<td></td>
</tr>
<tr>
<td>Tin</td>
<td>5,000</td>
<td>48 *</td>
</tr>
<tr>
<td>Uranium</td>
<td>56,000</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>Zn 7,000-38,000</td>
<td></td>
</tr>
<tr>
<td>Lead 210</td>
<td>0.5 *</td>
<td></td>
</tr>
<tr>
<td>Potassium 210</td>
<td>0.3 *</td>
<td></td>
</tr>
<tr>
<td>Sodium 256</td>
<td>0.1 *</td>
<td></td>
</tr>
<tr>
<td>Sulfides</td>
<td></td>
<td>130,000 M</td>
</tr>
</tbody>
</table>

# Footnotes:
- Based on QCA approach using sensitive species HOS; ES&T 2006 50(1):5148-5166.
- * Based upon EOPP approach using current AWGC CCC.
- † Based on QCA approach to derive LEL and SEL; Environ Monitor & Assessment, 2005 110:71-85.
- ‡ Carried over from Open Water disposal guidelines; treated as if LEL for management reasons.
- ‡infraunal community impacts.
- Dose endpoints: M – Microtox; B – Bivalve; E – Echinoderm larvae; O – Oyster larvae; A – Amphipod.

# Sources:
- EPA 005 R06.009
- Arch ETC 2000, 39(120)- Also known as Canadian ISQO's and PELs.
- E fate 1996, 50(9):235-.
- EPA 005R-00307.
- Envl/Mng 1005, 10(1):61-.
Sediment Quality Guidelines

- Interpret historical data
- Source control
- Design monitoring programs
- Classify hot spots
- Identify potential problem chemicals or areas at a site
- Make decisions for more detailed study
But they do not provide cleanup concentrations.

Nor were they ever designed to...
Development of consensus-based sediment quality guidelines (SQGs) for fresh water:

- Probable effect concentrations (PECs)
- Threshold effect concentrations (TECs)

Evaluate the predictive ability of SQGs:

- *Hyalella azteca*: 10- to 14-d tests (n=668)
- *Hyalella azteca*: 10- to 42-d tests (n=160)
- *Chironomus tentans*: 10- to 14-d tests (n=632)
Fig. 1: Incidence of toxicity below TEC, between TEC and PEC, and above PEC for metals

Incidence of toxicity (%)

As Cd Cr Cu Pb Hg Ni Zn

<TEC  TEC to PEC  >PEC
Fig. 2: Incidence of toxicity below TEC, between TEC and PEC, and above PEC for PAHs
Q2

Is it ecologically worse to find several contaminants above the PEC or is it equally bad to find just one above the PEC? Does it make more sense to assess contaminants individually or as a composite in terms of ecological impacts?
Predictive Ability of SQGs:

Evaluate approaches for evaluating effects of chemical mixtures on toxicity in field-collected sediments.

- Mean PEC quotients:
  1. Divide concentration of chemical by PEC.
  2. Sum individual quotients.
  3. Calculate mean quotient/sample.

Evaluate ability of PECs to predict sediment toxicity in a freshwater database on a national and regional basis.
ERM\-Q = \frac{1}{n} \sum_{i=1}^{n} \frac{COC_i}{ERM_i}
PEC Quotients

<0.1 = 18%
0.1 - <0.5 = 16%
0.5 – 1.0 = 37%
>1.0 = 54%
>5.0 = 71%

From: Ingersoll et al., 2001
Relationship between mean PEC-Q and the incidence of toxicity in freshwater sediments (n=347).

\[ r^2 = 0.98 \]

\[ Y = 101.48(1 - 0.36^x) \]
# of PELs / ER-Ms Exceeded

- 1 = 14% / 23%
- 2 = 38% / 37%
- 3 = 35% / 24%
- 4 = 22% / 63%

Percent = Highly Toxic

From: Long et al., 1998
Q3

Are some contaminants worse than others ecologically? Or, if you are over the PEC, then you are equally bad? Is it worse if we find PCBs or chromium, for example? We generally need rules of thumb for when we should be really concerned versus when we just need to have a basic management plan. Can the ecological impacts of contaminants change based on setting? Will the same concentration have different ecological effects based on geology or water chemistry or in different parts of a river?
PCBs: Often low toxicity in 10-day tox tests but bioaccumulates and biomagnifies. Some CBRs are available. SQGs are low.

PAHs: Toxic to benthic organisms but generally does not accumulate in finfish. Use histopathology or biomarkers.

Metals: Toxic to benthic organisms but generally does not bioaccumulate or biomagnify in fish (except Hg and Cd).

Mercury: SQGs show low accuracy. MeHg is the more toxic form. Bioaccumulates and biomagnifies.

Dioxin: Most difficult to address. No SQG, need TCDD Toxicity Reference Value after TEC (TEQ) calculation.

But likely finer grained, higher TOC and AVS in impoundments.
Q4

How effectively do dams store contaminants? Are contaminants typically bioavailable when left impounded behind dams? Are some types of contaminants more likely to be bioavailable if left impounded behind dams?
Fine grained material moves downstream faster than larger sized sediment.

Sediment behind dams is usually more fine grained. More surface area to capture contaminants.

But also more surface area to capture organic carbon.

As before Hg, PCBs, and to a lesser extent dioxin bioaccumulate the most but may not be acutely toxic.
Q5
One of our most important questions: If the downstream condition of a river is less contaminated (such as the Concord River), would we do additional ecological harm by releasing more contaminants by removing a dam? How do we make this decision? Is it better to release it all quickly at one time through dam removal than have a slow release from storage in an impoundment over time? During the dam removal, should we release contaminants in pulses, all at once, or make sure that we don’t release a single ounce?
I do not believe there is a perfect answer. If you show the sediment is toxic, it should be removed. Of course the solution to pollution is dilution but that might be a hard sell. A sediment transport/contaminant model could help though.
Toxicity Testing Costs

- 10-day Hyalella test: $1000 for survival endpoint only, $1100 for both survival and growth endpoints
- 10-day Chironomus test: $1000 for survival endpoint only, $1100 for both survival and growth endpoints

If there are more than five samples costs generally start to decrease per sample.
Chemistry costs

- Metals: $180
- SVOC: $320 to $520
- PCBs: $160
- Pesticides: $180
- Conventional Parameters: $200

If there are more than five samples costs generally start to decrease per sample.
Risk Assessment

Risk assessment is a process where information is analyzed to determine if an environmental hazard might cause harm to exposed persons and ecosystems.

Paraphrased from “Risk Assessment in the Federal Government” (National Research Council, 1983)
What Is Risk?

Definition: Probability of harm or loss

\[ \text{Risk} = \text{Hazard} \times \text{Exposure} \]

- Part of our everyday lives
- Different for each of us
- For example, at EPA, risk is the likelihood or probability of:
  - A case of cancer
  - Some adverse effect such as a birth defect or asthma
  - Adverse effect on wildlife
A risk does not exist unless:

- the stressor has the ability to cause one or more adverse effects, and
- it co-occurs with or contacts an ecological component long enough and at a sufficient intensity to elicit the identified adverse effect.
Uses of Eco Risk Assessment

- Inform agencies & public of baseline risk
- Determine need for remedy
- Identify threshold concentrations for effects and cleanup goals
- Evaluate risk of remedy
- Recommend remedial monitoring endpoints
Simplified Foodweb

- Fish
- Plankton
- Benthos
- Reptiles
- Submerged Vegetation
- Surface Water
- Sediment
- Emergent Vegetation
- Birds
### Typical Measurement Endpoints for Sediment Assessment

<table>
<thead>
<tr>
<th>Assessment Tool</th>
<th>Exposure</th>
<th>Direct Msr of Effect</th>
<th>Effects from Lit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Chemistry</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Sediment Chemistry</td>
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<td></td>
<td>X</td>
</tr>
<tr>
<td>Tissue Chemistry</td>
<td>X</td>
<td></td>
<td>?</td>
</tr>
<tr>
<td>Sediment Toxicity</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Benthic Macroinvert. Community Analysis</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Histopathology</td>
<td></td>
<td>X</td>
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</tr>
<tr>
<td>Biomarkers</td>
<td>X</td>
<td>?</td>
<td></td>
</tr>
</tbody>
</table>
USEPA Testing Protocols (USEPA 2000)

- Test Method 100.1: *Hyalella azteca* 10-day (acute) Survival and Growth Test for Sediments

- Test Method 100.2: *Chironomus tentans* 10-day (acute) Survival and Growth Test for Sediments
Metal concentrations are high but not extreme

Aluminum City (Cu, Zn) and Powdermill As, Cd, Cr, Cu, Pb, Ni, Zn and especially PAHs) impoundments have higher concentrations

But all impoundments have some hot spots

Hudson impoundment likely non-toxic from metals but PAHs another story
Data may help determine source

- Ben Smith Impoundment Station BS38 shows lead at 3800 mg/kg. Nearly 30X greater than the PEC.
- Now this is something to get your attention
- Yet deeper seds are okay and other metals are not extremely elevated.
- An artifact?
Data may help determine source

- Powdermill impoundment Stations P53 and P54
- Adjacent to the wastewater treatment plant
- Very high inorganics
- High PAHs (around 100 ppm) but even higher upstream
- Station P50/52 is of concern. PAH = 1100/180 ppm. Not near dam-1000m, Source =?
- Powdermill is a PAH sink. Why?
Other Hot Spots  3XPEC

- Alum City AC4, near dam, Cr at depth
- Allen St. AS8, Cu at depth, much sed.
- Gleasondale G22, Ni at surface  (?)
- Hudson H10, PAH at surface  (?)
- Gleasondale G18, PAH at surface and at depth  Also PCBs at 3.1ppm  (?)
Quick Summary

- Powdermill likely the most toxic
- Ben Smith and Allen Street the least

Nevertheless, we have no data to support the claim that the sediments are toxic.
- We are also missing TOC and AVS
Phosphorus

- Not my expertise

- The USGS states that the amount of phosphorus released from the sediments is small compared to that entering the system from upstream wastewater treatment plants.
QUESTIONS