Lake Bottom Sediments: An Archive of Historical Human Activity and its Environmental Effects

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Every lake has a story to tell...

...and part of that story is told by the bottom sediment.

USGS
Bottom sediment can provide current and historical information about:

1. Nutrients.
2. Trace elements.
3. Other contaminants.
4. Biological indicators.

Which can be used to:

1. Determine effects of human activity.
2. Assess habitat quality.
3. Reconstruct historical conditions.
4. Assess changes in trophic conditions.
5. Identify constituents of concern.
6. Provide a baseline for future assessments.
Top 20 Hazardous Substances from the CERCLA Priority List of Hazardous Substances for 2011

1. Arsenic
2. Lead
3. Mercury
4. Vinyl Chloride
5. PCBs
6. Benzene
7. Cadmium
8. Benzo(a)pyrene
9. PAHs
10. Benzo(b)fluoranthene

*Hydrophobic

11. Chloroform
12. Aroclor 1260
13. DDT
14. Aroclor 1254
15. Dibenzo(a,h)anthracene
16. Trichloroethylene
17. Chromium, hexavalent
18. Dieldrin
19. Phosphorus, white
20. Hexachlorobutadiene

# Sediment-Quality Guidelines

<table>
<thead>
<tr>
<th>Trace element</th>
<th>USEPA (1997)</th>
<th>MacDonald et al. (2000)</th>
<th>Bio-accumulation index$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TEL</td>
<td>PEL</td>
<td>TEC</td>
</tr>
<tr>
<td>Arsenic</td>
<td>7.24</td>
<td>41.6</td>
<td>9.79</td>
</tr>
<tr>
<td>Cadmium</td>
<td>.676</td>
<td>4.21</td>
<td>.99</td>
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<tr>
<td>Chromium</td>
<td>52.3</td>
<td>160</td>
<td>43.4</td>
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<tr>
<td>Copper</td>
<td>18.7</td>
<td>108</td>
<td>31.6</td>
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<tr>
<td>Lead</td>
<td>30.2</td>
<td>112</td>
<td>35.8</td>
</tr>
<tr>
<td>Mercury</td>
<td>.13</td>
<td>.696</td>
<td>.18</td>
</tr>
<tr>
<td>Nickel</td>
<td>15.9</td>
<td>42.8</td>
<td>22.7</td>
</tr>
<tr>
<td>Silver</td>
<td>.733</td>
<td>1.77</td>
<td>--</td>
</tr>
<tr>
<td>Zinc</td>
<td>124</td>
<td>271</td>
<td>121</td>
</tr>
</tbody>
</table>

Values in milligrams per kilogram.

$^1$source: Pais and Jones (1997)
Constituent Histories

- Selenium
- Lead
- Copper
- DDE
- Biological indicators
Constituent Histories

• Selenium
• Lead
• Copper
• DDE
• Biological indicators
An American coot embryo from Kesterson National Wildlife Refuge, California, with selenium-induced developmental abnormalities including a deformed lower bill and no eyes.

Courtesy H. M. Ohlendorf, U.S. Fish and Wildlife Service
Selenium in Reservoir Bottom Sediment: Republican River Basin
Irrigation History and Selenium Depositional Profiles in Reservoirs

(Juracek and Ziegler, 1998)
Constituent Histories

- Selenium
- Lead
- Copper
- DDE
- Biological indicators
Total Lead Emissions in U.S. 1970 to 1998

Modified from USEPA (2000)
Lead in Bottom Sediment of Crystal Lake: Decades for Recovery Following Phase Out of Leaded Gas

(Juracek, 2004; Juracek and Ziegler, 2006)
The Tri-State Mining District

- Tri-State Mining District
- Cherokee County superfund site
- Lead and zinc mined areas (Brightha, 1960)
- Boundary of Spring River Basin

07186000  Blackberry Hay Farm Lake
07187000  U.S. Geological Survey streamflow-gaging station and number

Grand Lake O’the Cherokees
Tri-State History

- Mining in the Tri-State Mining District, 1850-1970.
- World’s largest lead and zinc producer until 1945.
- Cherokee County superfund site established in 1983.
- Contaminants of concern: cadmium, lead, and zinc.

Photo: Baxter Springs Heritage Center and Museum
Lead concentrations have decreased over time, but still exceed probable-effects guideline.

(Juracek, 2006, 2008)
Lead concentrations have decreased since about the 1980s.

Lead concentrations were less than the probable-effects guideline.

Median lead concentration was about 5 times less than Empire Lake.
Constituent Histories

- Selenium
- Lead
- Copper
- DDE
- Biological indicators
Copper Sulfate to Control Algal Blooms
Copper in Bottom Sediment of Crystal Lake Documents Copper Sulfate Use

**Copper**

- Threshold-effects level (18.7 µg/g)
- Probable-effects level (108 µg/g)

**Cesium-137**

- 2003
- 1963-64

(Juracek, 2004)
Constituent Histories

- Selenium
- Lead
- Copper
- DDE
- Biological indicators
DDT

- Peak use in 1950’s and 1960’s
- Banned in 1972
- Degrades to DDD and DDE
DDE in Bottom Sediment of Tuttle Creek Lake Documents History of DDT Use in Basin

(Juracek and Mau, 2002)
 Constituent Histories

- Selenium
- Lead
- Copper
- DDE
- Biological indicators
Eutrophication: A Common Problem for Lakes

(microcystis bloom)
Diatoms and Akinetes: Indicators of Lake Trophic Conditions
Lake Maxinkuckee Possibly Has Become Less Eutrophic in Recent Decades

*Cyclotella bodanica*  
(oligotrophic indicator)

*Cyclotella pseudostelligera*  
(eutrophic indicator)
Cyanobacterial Akinetes Indicated Clinton Lake Became More Eutrophic

(Juracek, 2011)
Increase in Akinete Abundance at Clinton Lake Possibly Related to Increase in Phosphorus

(Juracek, 2011)
Benefits

- Determination of past/present environmental conditions
- Warning of potential problems
- Baseline for future assessments
- Information for management (e.g., TMDLs)
Has your lake’s story been told?
Questions?

For more information
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