Sediment Metal Concentrations in Selected Coves of Grand Lake O’ the Cherokees


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School of Civil Engineering and Environmental Science
The University of Oklahoma, Norman, OK
Background
2012 Capstone Project

- Outgrowth of long-term cooperative efforts
- Focus on reservoir sediment contamination
- Historic mining impacts
- Management implications
Grand Lake O’ the Cherokees

- Third largest reservoir in Oklahoma
- Beneficial uses
  - Hydroelectric power
  - Flood control
  - Water supply
  - Recreation
  - Fish and wildlife propagation
- Operated by GRDA

- 10,298 mi² watershed
- 46,500 surface acres
- 1,300 shoreline miles
- Pensacola Dam (1940)
- Largest multiple arch dam
Grand Lake O’ the Cherokees

- Premier recreation destination
- Near shore development
  - Boat docks
  - Sediment dredging

One weekend
$26 million economic impact
Tri-State Mining District

- 1200 mi² mined
  ~1838-1970

- Mississippian sulfides
  - Galena (PbS)
  - Sphalerite (ZnS)

- Four USEPA CERCLA Sites
Scope & Objectives
Project Scope

- Lake shore development often requires sediment dredging

- GRDA Shoreline Management Plan
  - Total metals concentrations compared to Sediment Quality Guidelines (SQGs)

- Examine sediment metal concentrations
Project Objectives

- Focus on metals associated with the TSMD
- Compare sediment metal concentrations to both general and site-specific SQGs
- Compare sediment metal concentrations in developed and undeveloped coves
Sampling Locations

Duck Creek Cove

Drowning Creek Cove
Duck Creek
Drowning Creek
Methodology
**Water – 1 m above sediment**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>In situ physical parameters</td>
<td>X</td>
</tr>
<tr>
<td>Total metals*</td>
<td>X</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>X</td>
</tr>
<tr>
<td>Nitrate</td>
<td>X</td>
</tr>
<tr>
<td>Nitrite</td>
<td>X</td>
</tr>
<tr>
<td>Ammonia</td>
<td>X</td>
</tr>
<tr>
<td>Phosphate</td>
<td>X</td>
</tr>
<tr>
<td>Turbidity</td>
<td>X</td>
</tr>
</tbody>
</table>

*Al, As, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Zn
## Sediment

- 2” diameter gravity corer
- Incremented 2” sections

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content</td>
<td>X</td>
</tr>
<tr>
<td>Organic matter</td>
<td>X</td>
</tr>
<tr>
<td>Total metals</td>
<td>X</td>
</tr>
<tr>
<td>Total mercury</td>
<td>X</td>
</tr>
</tbody>
</table>
Results
Water Quality Results

- Phosphate > in-lake criteria in all samples
- Ammonia and nitrate < in-lake criteria
- Cd > chronic criteria at DCK-1
Sediment Quality Guidelines

- Adverse effects not expected to occur
- Neither predicted to be toxic or nontoxic
- Adverse effects expected to occur more often than not

Threshold Effect Concentration
Probable Effect Concentration

Measured Concentration

Depth
Zn > TEC at 9 sites
Zn > PEC at 1 sites
Zn< T-PEC at all sites
Cd > TEC at 9 sites
Cd < T-PEC at all sites
Pb > TEC at 8 sites
Pb < T-PEC at all sites
<table>
<thead>
<tr>
<th>Parameter</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cd Concentration</td>
<td>0.0001915</td>
</tr>
<tr>
<td>0-2 Inches increment Cd</td>
<td>0.007787</td>
</tr>
</tbody>
</table>

p-values < 0.05
<table>
<thead>
<tr>
<th>Parameter</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Pb Concentration</td>
<td>3.652e-0.5</td>
</tr>
<tr>
<td>0-2 Inches Increment Pb</td>
<td>0.003615</td>
</tr>
</tbody>
</table>
### Mean [Zn] (mg/kg)

- **Parameter**: Total Zn Concentration
- **p-value**: $4.504e^{-07}$

### 0-2 Inch Increment [Zn] (mg/kg)

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<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Zn Concentration</td>
<td>$4.504e^{-07}$</td>
</tr>
<tr>
<td>0-2 inches increment Zn</td>
<td>0.02533</td>
</tr>
</tbody>
</table>

**p-values < 0.05**
Conclusions – Water

- Lake water quality
  - Turbidity and phosphorus exceed applicable criteria
  - Cd > chronic criteria in one sample; requires rechecking
Conclusions – Sediment Metals

- Shoreline Management Plan dictates further action if $[M+] >$ general TEC

- Some $[M+]$ exceed general TEC and PEC, but none exceed site-specific PEC

- Metals concentrations at Duck Creek (developed) are greater than Drowning Creek (undeveloped)
For site-specific SQGs, none of the sediment increments exceeded the PEC values.

<table>
<thead>
<tr>
<th></th>
<th>%G-TEC Exceedance</th>
<th>% G-PEC Exceedance</th>
<th>% T-PEC Exceedance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DCK</td>
<td>DRN</td>
<td>DCK</td>
</tr>
<tr>
<td>Cd</td>
<td>100</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Pb</td>
<td>91</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>Zn</td>
<td>100</td>
<td>67</td>
<td>38</td>
</tr>
</tbody>
</table>
Recommendations

- Further sediment research needed
  - Sample more coves
  - Collect more cores
  - Complete particle size analyses
  - Age-date cores
  - Assess native soils

- Disposal plans must be considered prior to dredging
Acknowledgements

- Jacklyn Jaggars
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- GRDA EEC
Questions?

http://CREW.ou.edu