Residuals based approaches

Efficacy and costs

Sally Brown
Mark Sprenger
Jasper County
US EPA NPL site

• Tailings project started in 1999
• Back when I was young....
Large-scale biosolids demo

- Biosolids + lime applied at low and high rates to sites in the New Repository and Old Repository
- Composts tested by MO DNR
Ecological Risk Assessment
Mark Sprenger US EPA
Soil Zn
Plant Zn

2001
2012

![Zinc Levels in Soil and Plant 2001 and 2012](chart.png)
2002-

- Trapping rate 19%
  - Normal 3-5%

- 92 kidneys collected
  - 61 normal
  - 22 indication of Cd exposure
  - 4 potential function compromise
  - 9 not able to analyze
Control
5% Cover
0 Yield

Low Biosolids
50% Cover
14.5 Yield
High Biosolids
94% Cover
47 Yield

Topsoil
92.5% Cover
44 Yield
<table>
<thead>
<tr>
<th>Treatment</th>
<th>M3 P</th>
<th>Total C</th>
<th>Bulk Density</th>
<th>% H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>133</td>
<td>0.56</td>
<td>1.52</td>
<td>3.63</td>
</tr>
<tr>
<td>Biosolids high</td>
<td>738</td>
<td>6</td>
<td>0.82</td>
<td>30.5</td>
</tr>
<tr>
<td>Topsoil</td>
<td>17</td>
<td>2.75</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Jasper one of many

Bunker Hill, ID

Leadville, CO

Bunker Hill, ID

Wetland

Joplin, MO

Tar Creek, OK
Surface application of biosolids and wood ash

Biosolids sugar beet lime, CaO

Biosolids and lime, incorporated

Lime stabilized biosolids + Fe
A similar risk assessment was also carried out in Leadville.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Untreated</th>
<th>Treated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shoot (mg)</td>
<td>Root (mg)</td>
</tr>
<tr>
<td>CL</td>
<td>no germination</td>
<td>no germination</td>
</tr>
<tr>
<td>CO</td>
<td>no germination</td>
<td>no germination</td>
</tr>
<tr>
<td>MB/ME</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>RA/RB</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ref. A</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Upst. Ref.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lab Con.</td>
<td>9.72</td>
<td>16.26</td>
</tr>
</tbody>
</table>

* significantly < reference samples
Both Jasper and Leadville showed ecosystem function had been restored.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Untreated Survival (%)</th>
<th>Untreated Biomass (mg)</th>
<th>Treated Survival (%)</th>
<th>Treated Biomass (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL</td>
<td>0</td>
<td>NA</td>
<td>100.0</td>
<td>329.3</td>
</tr>
<tr>
<td>CO</td>
<td>0</td>
<td>NA</td>
<td>98.9</td>
<td>323.0</td>
</tr>
<tr>
<td>MB/ME</td>
<td>0/0</td>
<td>NA</td>
<td>90.0</td>
<td>372.0</td>
</tr>
<tr>
<td>RA/RB</td>
<td>0/0</td>
<td>NA</td>
<td>10.0*</td>
<td>280.3</td>
</tr>
<tr>
<td>Ref. A</td>
<td>-</td>
<td>-</td>
<td>98.7</td>
<td>244.0</td>
</tr>
<tr>
<td>Upst. Ref.</td>
<td>-</td>
<td>-</td>
<td>96.7</td>
<td>196.0</td>
</tr>
<tr>
<td>Lab Con.</td>
<td>100</td>
<td>not measured</td>
<td>100.0</td>
<td>258.6</td>
</tr>
</tbody>
</table>

* significantly < reference samples and/or control sample
Amendments work
Google maps for the test of time
Leadville, CO
And we make more every day

• If first attempt is unsuccessful, easy to reapply
• You are effectively building soil at a highly accelerated rate
• Not a precise science
But they can be a pain

- Working with generators
- Regulatory issues
- Supply issues
- Transport issue

Harvesting topsoil - easy and proven alternative
Environmental Costs

- Topsoil replacement
  - 15 cm

- Biosolids/residuals
  - 336 Mg
Topsoil

Current accounting
• Pay the farmer
• Pay the transport

Ecosystem accounting
• Attempt to put a value on the services we get from nature
• 1997 Ecosystem services worth $33 trillion annually
• 17% of New Zealand GDP from soil
How much is soil worth?

CRP Value

- Soil formation is 0.003 inches per year (Montgomery, 2007)
- That means it would take more than 1800 years to build 6” of topsoil
- Compost/biosolids/organics can do it in a month
- Based on annual CRP payments of $128 per hectare—that comes to $241,000 to rebuild a soil
607,000 hectares of mine impacted lands = 6700 km² = 0.5 Los Angeles

6700 km² = 670,000 ha
670,000 * $ 241 000

$160.8 Billion
Residuals instead then

- Biosolids
  - MO produces 227,000 dry tons annually
  - 60% are incinerated
    - 136,200
    - Enough for 402 ha per year
$$ of biosolids (as CO$_2$e) per 336 tons or 1 ha

- **Combustion**
  - Energy to dry 1.2
  - Fugitive N2O emissions 483
  - Transport 0.6

- **Total emissions**
- 485 tons CO$_2$ per ha

- **Restoration**
  - Fertilizer credit -80
  - Soil carbon storage -89
  - Transport 8

- **Total sequestration**
- -156 tons CO$_2$ per ha
People aren’t the only things that poop

<table>
<thead>
<tr>
<th>Animal</th>
<th>Animal number</th>
<th>Total US dry tons produced (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy Cow</td>
<td>9</td>
<td>18.6</td>
</tr>
<tr>
<td>Beef Cattle</td>
<td></td>
<td>25.8</td>
</tr>
<tr>
<td>Swine</td>
<td></td>
<td>25.8</td>
</tr>
<tr>
<td></td>
<td>Finish</td>
<td>120</td>
</tr>
<tr>
<td>Poultry</td>
<td></td>
<td>25.8</td>
</tr>
<tr>
<td></td>
<td>Layer</td>
<td>292</td>
</tr>
<tr>
<td></td>
<td>Broiler</td>
<td>8,600</td>
</tr>
</tbody>
</table>


Conclusions

• Residuals based restoration effective over long term
  – Animal endpoints
  – Plant endpoints

• Alternate accounting
  – True cost of soil harvesting
  – True value of residuals based approaches