A nuanced approach to clean-up

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Mission evolving beyond human health protection

Restoration ecosystem services

Protection of wildlife
Ecosystem Example
Tri-State Mining District

http://www.kgs.ku.edu/Publications/pic17/pic17_1.html
Jasper County

- Tailings project started in 1999
- Extensive area of mine waste ‘chat’
Large-scale demo

- Biosolids + lime applied at low and high rates to areas within the site
- Composts and other amendments included
- Topsoiling traditional remedy
Short and long term sampling
Focus on ecosystem function/safety
Soil Zn
Plant Zn

2001
2012
The bar chart shows the weight of worms in different soil conditions. The x-axis represents the different soil types: Tailings, Amended -A, Amended-B, and Clean soil. The y-axis represents the worm weight. The chart indicates that the worm weight is highest in the Tailings condition, followed by Amended-B, Amended -A, and Clean soil. The chart also shows the concentration of Cd in worms (Worm Cd), with the highest concentration in the Tailings condition.
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
## Soil measures

<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

Surface application of compost and wood ash

Biosolids and lime, incorporated

Lime stabilized biosolids + Fe
Amendments work
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
Rather than

- Rate of soil formation
  - 0.058 to 0.083 mm yr\(^{-1}\)
  - 1875-1900 years to replace top 15 cm
  - No farming during that time
- USDA Conservation Reserve Program
  - $241,000 per ha
607,000 hectares of mine impacted lands = 6700 km\(^2\) = 0.5 Los Angeles

6700 km\(^2\) = 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
607,000 hectares / 402 ha biosolids per year

1 667 years

7.2 million tons produced annually
50% beneficially used = 3.6 million tons available
10,714 acres per year = 57 years
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>25.8</td>
<td>32.8</td>
</tr>
<tr>
<td>Swine</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Finish</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Layer</td>
<td>292</td>
</tr>
<tr>
<td></td>
<td>Broiler</td>
<td>8 600</td>
</tr>
<tr>
<td>Poultry</td>
<td></td>
<td></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