Spatial and Temporal Migration of a Landfill Leachate Plume at Norman Landfill Research Site

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There will be 6 more talks over research from Norman.

- **Isabelle Cozzarelli** -- “Long-term biogeochemical evolution of the leachate plume”
- **Joe Suflita** – “Microbial activity and its influence on organic matter quality”
- **Victoria Parisi** -- “The implications for anaerobic methane oxidation”
- **Bob Eganhouse** – “Endocrine disrupters” and new technology for the determination of nonylphenol isomers”
- **Michelle Lorah** – “Natural attenuation of landfill contaminants at the ground-water/surface-water interface”
- **Tara Kneeshaw** – “Kinetic controls on sulfate reduction at hydrologic interfaces”
The Norman Landfill Site

- Selected to gain a greater understanding of the hydrological, biological, geochemical processes controlling the fate of landfill contaminants.
- Site is a model for approximately 100,000 closed and active landfills across the United States.
- Historical research dating back 30 years.
- Site serves as a environmental laboratory for process-oriented research.
Norman Landfill

- Municipal landfill operated from early 1900’s to 1985
- Accepted unrestricted solid waste
- Unlined
- Closed in 1985 covered with clay and vegetation
- Selected as point-source research site in 1994
• The Canadian River Alluvium consists of unconsolidated layers of clay, silt, sand, and gravel transported and deposited by the River (median $k = 6.6 \times 10^{-5}$ m/s).

• Groundwater velocity, median $k$ is 13 m/year, aquifer base 50 m/year.

• Shallow depth to water.

• These river valleys are subject to periodic flooding, making such land low in cost for public uses such as landfills or parks.
The old Norman Landfill has no liner or leachate collection system. A leachate plume has developed.
Norman Landfill, November 1966

Norman Landfill Showing Closure Operations in 1985
Potentiometric Surface at Norman Landfill, Winter 1995-96

- Each line represents 10 cm.
- Direction of GW flow.
- Site includes a natural wetland "The Slough".
- Hydraulic gradient: North of landfill 2.8 m/km, South of landfill 1.4 m/km.
Mapping the Spatial Extent of The Leachate Plume

• 1996, Water-Resources Investigations Report 01-4168, hydrogeology and leachate plume delineation.

• 2000, Thesis work about the characteristics of the Canadian River Alluvium by DeHay, Paxton, and Marston.

• 2008, recent field sampling.
Specific conductance measured during 1996 timeframe, in microsiemens per centimeter

- 1500 - 2000
- 2001 - 3000
- 3001 - 4500
- 4501 - 6000
- 6001 - 7500
- 7501 - 9000

1996 Time Period

- Specific conductance contours were digitized.
- Southern landfill toe used to represent the up-gradient edge of plume.
- Contour value 2500 used to represent down-gradient edge of plume.
- Calculated area, 50,793 m²
2000 Time Period

- Geoprobe used to measure continuous soil conductivity.
- Average soil conductivity calculated.
- Southern landfill toe used to represent the up-gradient edge of plume.
- Contour value 60 used to represent down-gradient edge of plume.
- Calculated area, 95,639 m²
2008 Time Period

✓ Collect water samples from multi-level wells.
✓ Southern landfill toe used to represent the up-gradient edge of plume.
✓ Contour value 200 used to represent down-gradient edge of plume.
✓ Calculated area, 180,621 m²

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Canadian River Alluvium</th>
<th>Norman Landfill Plume</th>
<th>Other Landfill Plumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride (mg/L)</td>
<td>5-100</td>
<td>200-1200</td>
<td>10-3800</td>
</tr>
</tbody>
</table>
Plume Area in 1996, 2000, and 2008

- **1996**: 50,793 m²
- **2000**: 95,639 m²
- **2008**: 180,621 m²
Migration of Plume in 2D
1996 to 2000

- Symmetrical difference
  \((-7,516.2 \text{ m}^2 + 52,362.6 \text{ m}^2)\)
  \(= 44,864.4 \text{ m}^2\)

- 88.3 percent increase,
  \(\frac{(b - a)}{a} \times 100\)
Migration of Plume in 2D
2000 to 2008

- Symmetrical difference
  \((-736.9 \text{ m}^2 + 85,718.1 \text{ m}^2) = 84,981.2 \text{ m}^2\)

- \text{88.9 percent increase,}
  \(\frac{(b - a)}{a} \times 100\)
Migration of Plume in 2D
1996 to 2008

- Symmetrical difference
  \((-5,389.3 \text{ m}^2 + 135,217.0 \text{ m}^2)\)
  \(= 129,827.7 \text{ m}^2\)

- 255.6 percent increase,
  \((b - a) / a \times 100\)
Aerial Rates of Plume Migration

1996 to 2000
- 30.7 m²/day or 1.13 hectares/year

2000 to 2008
- 29.1 m²/day or 1.05 hectares/year

1996 to 2008
- 29.6 m²/day or 1.10 hectares/year
Summary

• Introduction of research site.
  - Background on the landfill.
  - Characteristics of the site.

• A leachate plume exist and from 1996 to 2008 has expanded at an aerial rate of 29.6 m²/day or 1.1 hectares/year.

• http://ok.water.usgs.gov/norlan/