Single- and double porosity modeling of solute transport in intact soil columns – effects of texture, slurry placement, and intermittent irrigation

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Animal Manure Application Techniques

Comparing surface application and injection of dairy cattle slurry
- Effect of soil texture (Glæsner et al. 2011a, Glæsner et al. 2011b)
- Effect of intermittent irrigation (Glæsner et al. 2011c)

Experimental Setup
- Intact soil columns 20 cm dia., 20 cm high from plow layer
- Irrigation rate irrigation 4.8 cm day$^{-1}$
- Unsaturated conditions (suction of -5 hPa at lower boundary)

Analysis
- $^3$H$_2$O transport (applied with irrigation water)
- Br transport (mixed with slurry)
- (Phosphorus transport)

Modeling with HYDRUS-1D – Exchange of solutes

1. Effect of injection (texture)
2. Effect of intermittent irrigation (loam)
Model Approach – Soil hydraulic parameters

Testing 2 parameter sets
- RETC from retention data of small (100 cm³) intact cores
- Rosetta from texture

x: Retention of small cores
O: Measured water contents of large columns

Model Approach – Solute transport parameters

**CXTFIT** (STANMOD) – continuous irrigation
before slurry application
flow conditions

**HYDRUS-1D** – parameters for continuous irrigation – **variables**

Compare:
- single porosity
- double porosity

Model Approach – Initial and boundary conditions

Lower boundary: seepage face

Slurry injection – double porosity MIM

Lower boundary: seepage face
**Results - Bromide leaching – slurry placement**

<table>
<thead>
<tr>
<th></th>
<th>Br Recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface applied</td>
<td>Injected</td>
</tr>
<tr>
<td>Loamy sand</td>
<td>85.2 (12.1) 79.0 (9.3)</td>
</tr>
<tr>
<td>Sandy loam</td>
<td>73.6 (8.5) 73.7 (4.5)</td>
</tr>
<tr>
<td>Loam</td>
<td>80.6 (6.3) 60.2 (2.3)</td>
</tr>
</tbody>
</table>

Single and double porosity MIM models: Decreased cumulative solute exchange from immobile to mobile regions with injection in loam.

**Results - Bromide leaching – intermittent irrigation**

<table>
<thead>
<tr>
<th></th>
<th>Br Recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous</td>
<td>45.5 (2.5)</td>
</tr>
<tr>
<td>Intermittent</td>
<td>59.3 (5.2)</td>
</tr>
</tbody>
</table>

Double porosity MIM model: Increased cumulative solute mass exchange from immobile to mobile regions with intermittent irrigation.

**Conclusions**

- The models described the data reasonably well.
- Slurry injection decreased solute mass exchange in loam.
  - Protection of slurry compounds when placed inside the soil matrix in fine-textured soils compared with placement of slurry at the soil surface.
- Introducing rainfall interruptions might increase mass exchange of slurry solutes placed within the soil matrix from immobile to mobile pore regions.
  - Might lead to higher leaching compared with steady flow conditions.

Thank you for your attention.