Mobility of Heavy Metals in Soils Ten Years After Sludge Applications

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Note: Press ‘skip’ on remote to advance slides.
Mobility of Trace Metals in Soil Ten Years after Sludge Application

Department of Biological & Environmental Engineering

I. Background

The increased use of wastewater sludge as fertilizers has raised a number of environmental and health concerns due to the considerable levels of toxic metals found in these waste materials. Soil columns that received a heavy loading of sludge were investigated 10 years later to determine the fate of trace metals applied in the soil.

A total of 30 undisturbed soil columns were operated in a greenhouse for 10 years (2 crop cycles) with sludge applied at various sludge processing and application rates. Previous studies indicate that slurred sludge has caused heavy leaching of some metals, although low as a percentage of metal loads. Cumulative sludge loadings were 213 dry T/ha, or roughly 30 years' worth of ammonia loadings. The following 4 soil columns were selected to measure trace metal movement through the undisturbed subsurface layers in the columns:

<table>
<thead>
<tr>
<th>Sludge Type</th>
<th>Soil Type</th>
<th>Initial Soil pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshwater</td>
<td>Hudson Soil Science</td>
<td>6.2 &amp; 7</td>
</tr>
<tr>
<td>Amended sandy loam</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

II. Data

A. Soil pH Analysis

The pH analysis clearly indicates the acidification of the soil columns due to sludge application and synthetic acid rainfall. These columns are strongly acidified throughout the profile.

B. Copper

Copper analysis at pre-treatment levels is deeper layers.

- Both pH 7 columns have enhanced levels of copper in subsurface soil, but only in the flow paths.
- Copper content at pre-treatment levels is deeper layers.
- pH 7 columns suggest deeper enhancement of copper throughout the profile.

C. Zinc

- As pH 7, zinc shows little movement in flow path. (Hudson pH 7 not shown due to difficulty with extraction/ICP analysis with samples).
- Cadmium, at such lower concentrations, was extremely sensitive in any variations.
- Amended sandy loam displays clear depletion in flow path in zone 1.

D. Cadmium

E. References

I. Background
The increased use of wastewater sludge as fertilizers has raised a number of environmental and health concerns due to the considerable levels of toxic metals found in these waste materials. Soil columns that received a heavy loading of sludge were investigated 10 years later to determine the fate of trace metals applied in the soil.

A total of 90 undisturbed soil columns were operated in a greenhouse for 10 years (15 crop cycles) with various sludge processing, soil type, and soil pH management treatments. Previous studies indicate that dewatered sludge had notable leaching of some metals, although low on a percentage of metal loaded. Cumulative sludge loadings were 215 dry t/ha, or roughly 30 years’ worth of agronomic loadings. The following 4 soil columns were selected to measure trace metal movement through the undisturbed subsoil layers in the columns:

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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Dewatered</td>
<td>Hudson Silt Loam</td>
<td>5 &amp; 7</td>
</tr>
<tr>
<td></td>
<td>Arkport Sandy Loam</td>
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II. Samples
✓ Blue-dying of soil highlights the preferential flow paths
✓ Nitric acid extraction → ICP analysis (metal concentration)

III. Data
Soil pH analysis

*Key on the bottom

<table>
<thead>
<tr>
<th>pH Level</th>
<th>Sample Zones</th>
<th>Hudson pH 5</th>
<th>Hudson pH 7</th>
<th>Arkport pH 5</th>
<th>Arkport pH 7</th>
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Copper

At pH 7, zinc shows little movement in flow path. (Hudson pH 5 not shown due to difficulty with extraction/ICP with samples).

Zinc

Cadmium

IV. Results & Trends

pH analysis clearly indicates the acidification of pH 5 columns due to sludge N & S acidification and synthetic acid rainfall. These columns are strongly acidified throughout the profile.

pH 7 columns show similar trends within each other. Due to such strong acidification, pH 7 columns were limed twice during cropping to maintain acceptable pH levels.

Both pH 7 columns have enhanced levels of copper in shallow subsoil zone 1, but only in the flow paths. Copper remains at pre-treatment levels in deeper layers.

*PH 5 columns suggest deeper enhancement of copper throughout the profiles.

In addition...
✓ Generally, metal total loss is greater in low pH columns.
✓ As expected, lead (Pb) had little mobility throughout the column but it had little consistency in data (graphs not displayed).
✓ It is quite a challenge to demonstrate changes in metal concentrations in non-homogeneous soil columns.

V. References

1. Background

The increased use of wastewater sludge as fertilizers have raised a number of environmental and health concerns due to the considerable levels of toxic metals found in these waste materials. Soil columns that had received a heavy loading of sludge were investigated 10 years later to determine the fate of trace metals applied in the soil.

A total of 90 undisturbed soil columns were operated in a greenhouse for 10 years (15 crop cycles) with various sludge processing, soil type, and soil pH management treatments. Previous studies indicate that dewatered sludge had notable leaching of some metals, although low on a percentage of metal loaded. Cumulative sludge loadings were 215 dry T/ha, or roughly 30 years’ worth of agronomic loadings. The following 4 soil columns were selected to measure trace metal movement through the undisturbed subsoil layers in the columns:

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II. Samples

- Blue-dying of soil highlights the preferential flow paths
- Nitric acid extraction → ICP analysis (metal concentration)

4 samples per each zone, topsoil, AND residue makes total of 34 samples per soil column.

Zones:
“1 – 4” as shown above; “top” is topsoil; “residue” means soil deposited on the lower plastic waterproof barrier.
III. Data

Soil pH analysis

*Key on the bottom

Copper

Sample Zones

Cu (mg/kg)

Hudson pH 5

Hudson pH 7

Arkport pH 5

Arkport pH 7
IV. **Results & Trends**

- pH analysis clearly indicates the acidification of pH 5 columns due to sludge N & S acidification and synthetic acid rainfall. These columns are strongly acidified throughout the profile.
- pH 7 columns show similar trends within each other. Due to such strong acidification, pH 7 columns were limed twice during cropping to maintain acceptable pH levels.

- Both pH 7 columns have enhanced levels of copper in shallow subsoil zone 1, but only in the flow paths. Copper remains at pre-treatment levels in deeper layers.
- pH 5 columns suggest deeper enhancement of copper throughout the profile.

(a) Soil columns were extracted by digging surrounding soil in Ithaca, NY (1993).
(b) Crops were planted on the soil columns to maintain active rhizospheres and to maintain preferential flow paths.
pH 5 columns suggest deeper enhancement of copper throughout the profiles.

At pH 7, zinc shows little movement in flow path. (Hudson pH 5 not shown due to difficulty with extraction/ICP with samples).

- Cadmium, at much lower concentrations, was extremely sensitive to any variations.
- Arkport pH 7 displays clear deposition in flow path in zone 1.

In addition...

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- As expected, lead (Pb) had little mobility throughout the column but it had little consistency in data (graphs not displayed).
- It is quite a challenge to demonstrate changes in metal concentrations in non-homogeneous soil columns.
V. References