Monitoring Nutrients from Greywater Irrigation: Performance of Different Lysimeter Types

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Environmental Technology Centre [ETC]

environmental technology for sustainable development

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Why Reuse Greywater for Irrigation?

2Q

Quantity

Quality
State Initiative

Complete a waste water recycling trial by June 2009 at 3 sites within the Metropolitan and Peel to demonstrate and evaluate the performance, reliability, attributes and feasibility of decentralised wastewater recycling.
Many greywater reuse systems have been approved for commercial use in Western Australia.

Of these households, 37% re-used greywater for gardening purposes – a percentage which has decreased from 2003 (44%) (WA Statistical Indicators, 2007)
Nutrients in Wastewater

Nitrogen Sources
- 80% of N in urine
- 20% from various sources: washing, faeces and cleaning products

Phosphorus Sources
- 50% of P in urine
- Up to 20% in household products
- The rest from various sources
Nutrient in Greywater

• Phosphorus and Nitrogen were used by the turf.
• Sodium and Chloride increased
• Grasses ability to only take up what is required

Greywater leachates into surrounding water bodies may contain nutrients in high enough concentration to cause harm to the environment such as algal bloom (Water Corporation, Department of Environment and Department of Health, 2005).
How does the nutrient leach?
1. What are the impact of our bathroom’s and laundry’s greywater on our soil?

2. What happen to the nearby water bodies especially groundwater?
1. Sandy soils: high potential for leaching

2. Clayey soils: increased pH and changes the soil structure

~ House owner should take adequate care in selecting household products to reduce the negative impacts.
The use of lysimeter

- To measure the quantity or rate of water movement through or from a block of soil, usually undisturbed and in situ, or to collect such percolated water for analysis.

- To extract soil solutions periodically for chemical analysis in order to monitor the presence and flow of nutrients and toxins in soils.
Examples of Lysimeter designs reported in the literature

<table>
<thead>
<tr>
<th>Test material</th>
<th>Parameters studied</th>
<th>Size of column (diameter:D, height:H, Area:A)</th>
<th>Material used for the column</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cores of sand and silt</td>
<td>Phosphor (inorganic and organic)</td>
<td>D:12.5cm, H:17.5cm</td>
<td>Perspex tube</td>
<td>Magid et al. (1992)</td>
</tr>
<tr>
<td>Cores of loam soil</td>
<td>Chloride</td>
<td>D:0.6m, H:1.52m</td>
<td>PVC</td>
<td>Corwin &amp; LeMert (1994)</td>
</tr>
<tr>
<td>Cores of loamy sand</td>
<td>Pesticides</td>
<td>D:20cm, H:98cm</td>
<td>Steel</td>
<td>Keller &amp; Weber (1995)</td>
</tr>
<tr>
<td>Krome (gravel)</td>
<td>Organic</td>
<td>5 gallon bucket</td>
<td>Plastic</td>
<td>Kati W M et al. (2006)</td>
</tr>
</tbody>
</table>
Nutrient Monitoring (2006-2007)

Monitoring Objective:
• To assess the potential impacts of nutrient leaching from greywater irrigation into groundwater.

Method:
• Samples were collected from driplines, leachates (using pan lysimeter) and groundwater.
• Nutrient analyses: P, Nitrate, TP, TN
Site Constraint

Close to an open water body (Peel-Harvey Inlet estuary)
Pan Lysimeter
Used During Monitoring Protocol
(2006-2007)

Figure 1: Lysimeter buried in the ground (adopted from Toofanee, 2007)
### Typical composition of greywater (DoH, 2005)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Greywater</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Range</td>
<td>Mean</td>
<td></td>
</tr>
<tr>
<td>Suspended Soilds</td>
<td>mg/L</td>
<td>45-330</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>22-&gt;200</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>BOD\textsubscript{5}</td>
<td>mg/L</td>
<td>90-290</td>
<td>160</td>
<td></td>
</tr>
<tr>
<td>Nitrite</td>
<td>mg/L</td>
<td>&lt;0.1-0.8</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td>mg/L</td>
<td>&lt;1.0-25.4</td>
<td>5.3</td>
<td></td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen</td>
<td>mg/L</td>
<td>2.1-31.5</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>mg/L</td>
<td>0.6-27.3</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Sulphate</td>
<td>mg/L</td>
<td>7.9-110</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>6.6-8.7</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>Conductivity</td>
<td>mS/cm</td>
<td>325-1140</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>Hardness</td>
<td>mg/L</td>
<td>15-55</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>mg/L</td>
<td>29-230</td>
<td>70</td>
<td></td>
</tr>
</tbody>
</table>
Monitoring Results

Phosphate Concentrations in three different sampling points

- Dripline
- Leachate
- Groundwater

**Phosphate Concentration (mg/L)**

- Singh (2006)
- Tofanee (2007)
Monitoring Results

Nitrate Concentrations in three different sampling points

<table>
<thead>
<tr>
<th></th>
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<tr>
<td>Dripline</td>
<td></td>
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</tr>
<tr>
<td>Leachate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groundwater</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The inconsistent/variable data produced from the previous nutrient research work and also in other studies has led to the design of an effective lysimeter to alleviate the detrimental impacts of nutrients on groundwater.
AIM: To develop a sustainable ZEN model with an effective lysimeter to monitor nutrient leaching from greywater irrigation in urban villages for land development.
NEW LYSIMETERS DEVELOPMENT
(10 March 2008 until 9 April 2008)

Group discussion

Auger demonstration by John Forrest

Two new lysimeters developed!

Development works
NEW LYSIMETER INSTALLATION ON 10th APRIL 2008
Compare with pan lysimeter installation
Schematic of Lysimeters trial site at ETC

Legend:
- Pan lysimeter
- New lysimeter (a)A
- New lysimeter (b)B
- Irrigation driplines
- Pipelines

Irrigation rates: 20 mm/day
ETC lysimeter test site

Aim: To determine the most efficient lysimeter by monitoring two different lysimeters; pan, and new designed.

Irrigation rates: 20 mm/day, volume and nutrient quality (TP, TN, nitrate, phosphate and ammonia) are being measured.
New design lysimeter

Figure 3: Schematic design for new lysimeters  (a) New lysimeter A with tubes in the column (b) New lysimeter B with tubes side of the column
Results

i) Leachate Quantity (Phase 1: 17/4/08 - 10/6/08)
Results

ii) Mean Volumes of Leachate (Phase 1)

Mean Volumes of Lysimeters, Phase 1 (17/4/08-10/6/08)

<table>
<thead>
<tr>
<th>Lysimeter type</th>
<th>Cell 1</th>
<th>Cell 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pan Lysimeter</td>
<td>1004±164 (n=18)</td>
<td>1187±202 (n=18)</td>
</tr>
<tr>
<td>New Lysimeter A</td>
<td>-Nil-</td>
<td>882±473 (n=9)</td>
</tr>
<tr>
<td>New Lysimeter B</td>
<td>202±243 (n=9)</td>
<td>-Nil-</td>
</tr>
</tbody>
</table>
Results

iii) Leachate Quantity
(Phase II: 18/6/08 - 24/7/08)
iv) Mean Volumes of Lysimeters (phase II)

<table>
<thead>
<tr>
<th>Lysimeter Type</th>
<th>Phase II (18/6/08 until 24/7/08), mL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cell 1</td>
</tr>
<tr>
<td>Pan Lysimeter</td>
<td>$1300 \pm 127$ (n=10)</td>
</tr>
<tr>
<td>New Lysimeter A</td>
<td>$1560 \pm 89$ (n=5)</td>
</tr>
<tr>
<td>New Lysimeter B</td>
<td>$270 \pm 233$ (n=5)</td>
</tr>
</tbody>
</table>
Leachate quality

Leachate mean concentration from lysimeter samplings collected monthly from April until July 2008, n=4 samples
Conclusions

Performance on different types of lysimeter:

i) Pan lysimeter: provides good volumes but difficult to install

ii) New lysimeter A: provides good volumes, simple and easy to install

iii) New lysimeter B: provides less volumes, but also simple and easier to install
Future Research:

Second Stage

1. Soil replacement
2. Nutrient (Phosphate and nitrate) adding
3. Turf planting
4. Nutrient mass balance
5. Effects on edge flow of the lysimeter
Monitoring Plans for Case Studies
(5 household greywater)

1. Pre activity: Sampling points determination, Lysimeter installation

2. Monitoring protocol:
   i) Greywater,
   ii) Soil (topsoil and subsoil)
   iii) Leachate
   iv) Plant
   v) Groundwater (before and after greywater irrigation area)

3. Post activity:
   i) Nutrient balance of the system
   ii) Simulation/modelling development
Thank You so much for your kind attention!!

Your valuable opinion and ideas are much appreciated to improve my research.

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