Urban metabolism and the need for final sinks
a case study of the city of Vienna

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Urban Metabolism

Material Imports

Material stock

Material stock

Recyclable materials

Non-recyclable materials

Products
We need sinks …

… that take up non-recyclable materials.

Environmental compartments

e.g. Landfills
A sink is a process with more input than output of a specific substance.

A final sink is a special kind of sink that either holds a substance no longer able to leave the sink by transport, or transforms a substance so that it does not exist in their original form anymore.

An appropriate final sink for a substance is a final sink where the concentration, speciation and mobility of a substance poses accepted environmental and health risks.
## Categorization of sinks

<table>
<thead>
<tr>
<th>Environment</th>
<th>Intermediate sink</th>
<th>Final sink</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anthroposphere</strong></td>
<td><code>- Storage: Storage facilities for waste</code>&lt;br&gt;<code>- Transport: Sewer channels for nutrients</code></td>
<td><code>- Storage: Sanitary Landfills for persistent substances</code>&lt;br&gt;<code>- Transformation: Thermal Treatment for organic substances</code></td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td><code>- Storage: Urban Soil for persistent substances</code>&lt;br&gt;<code>- Transportation: Two environmental compartments that exchange heavy metals</code></td>
<td><code>- Storage: Deep Sea Sediments for persistent substances</code>&lt;br&gt;<code>- Transformation: Ambient air for formaldehyde in smoke from cigarettes</code></td>
</tr>
</tbody>
</table>
Metric for sustainable resource use

(1) Substance flows

\[ \text{mass/time} \]

- non-recyclables I
- non-recyclables II
- intermediate sinks
- appropriate final sinks

(2) Indicator

\[ \alpha = \frac{\text{non} - \text{recyclables III}}{\text{non} - \text{recyclables I}} = \begin{cases} 1 & \text{if } 0 < \alpha < 1 \\ 0 & \text{otherwise} \end{cases} \]
Cu in the city of Vienna (Austria)
Opening the city as black box …

… through the visualization of Cu flows and stocks

Methodology: Substance Flow Analysis
### Cu flows in kg/cap yr

<table>
<thead>
<tr>
<th>Material</th>
<th>Imports</th>
<th>Recyclables</th>
<th>Products</th>
<th>Non-recyclables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12.3 ± 8%</td>
<td>+ 3.4 ± 33%</td>
<td>1.5 ± 29%</td>
<td>6.7 ± 5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.7 ± 6%</td>
</tr>
</tbody>
</table>
Where remain the non-recyclables?

- Emissions: 7 g/cap yr
- Wastes: 665 g/cap yr
- Spillway: 2 g/cap yr
- Effluent: 1 g/cap yr
- Surface runoff: 1 g/cap yr
- Compost: 1 g/cap yr
- Atmospheric deposition: 2 g/cap yr

Anthropogenic sinks:
- Selected APC residues: 10 g/cap yr
- Bottom-ash & APC residues: 655 g/cap yr

Environmental sinks:
- Receiving water
- Urban soil
- Underground storage
- Landfill

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[Image: http://upload.wikimedia.org/wikipedia/commons/9/93/Danube_between_Slovakia_and_Hungary_near_Patince_2.JPG]
\[ \alpha = \frac{665}{(665 + 7)} \approx 99\% \]

<table>
<thead>
<tr>
<th>Environment</th>
<th>Intermediate sinks</th>
<th>Appropriate final sinks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 g Cu/cap yr enter:</td>
<td>Options:</td>
</tr>
</tbody>
</table>
|             | o **Hydrosphere & Sediments**  
  Consistent measurements of HM concentrations in sediments are not available. | o Decrease emissions |
|             | o **Urban Soil**  
  Monitoring falls short in sound results. | o Increase separation efficiency of WWs |
| Anthroposphere | 665 g Cu/cap yr enter: | o Perform risk assessments & sound monitoring |
|             | o **Underground storage**  
  1 Barrier function  
  Accessibility | 3 barrier functions |
|             | o **Landfills**  
  3 barrier functions  
  Operational concept | |
Summery and conclusions

General
• A non-recyclable substance must be directed to an appropriate final sink.
• If it cannot be identified and/or utilized, the use of the substance has to be regulated.
• Cities have to monitor the efficiency in terms of routing substances to appropriate final sinks.

Cu case study
• Waste management sector provides vital sinks.
• Those sinks have to be managed to a certain extend.
• Non-point emission sources are as important as point-sources.
• An combination of risk assessment and monitoring for HM in urban soil & sediments is needed.
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