Recycling and Sustainability

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First goal of wm: direct materials to appropriate final sinks

River Danube

70 kg/(person·yr)
200 Mio. persons

Final sink
residence time > 10,000 years

Anthroposphere

Black Sea

Increase in salinity for 10,000 years: + 0.1%

-> Black Sea is an appropriate Final Sink for Cl⁻
"Planet earth" is a limited sink for wastes

Atmosphere 4.200 [Mio. km³]

Hydrosphere 1.400 [Mio. km³]

Pedosphere 0.3 [Mio. km³]

nach A. Nieman ergänzt durch G. Döberl
Sinks are overloaded by greenhouse gases

- CO₂: + 75%
- CH₄: + 300%
Sinks are overloaded by CFCs

Sinks are overloaded by DDT

National Geographic Image Collection
For most substances, we do not know sink capacities: e.g. Pd

Adopted from: C. Barbante et al., 2001
Waste management must supply appropriate „Sinks“

present sanitary landfill  future „Final Sink“ landfill

key barrier

envelope

waste properties

additional barriers
• natural attenuation
• monitoring

$\Phi_{\text{emission from landfill}} > \Phi_{\text{environment}}$

$\Phi_{\text{emission from landfill}} \sim \Phi_{\text{environment}}$
Waste treatment must produce „Final Sink“-quality

Döberl et al. (2001)
A major benefit of recycling is environmental protection

Scars from iron mining  Residues from aluminum production
Infrastructure: large potential to accommodate recycling products
Recycling products must comply with quality standards
### How to establish clean cycles from complex mixtures?

*Additive turn-over and stocks in plastic materials used in Austria*

<table>
<thead>
<tr>
<th>Material &amp; Additives</th>
<th>Total Consumption [kt/yr]</th>
<th>% in Packaging Material [%]</th>
<th>Total Stock [kt]</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Plastics</td>
<td>1,100</td>
<td>200</td>
<td>7,100</td>
</tr>
<tr>
<td>Softeners</td>
<td>14</td>
<td>0.2</td>
<td>140</td>
</tr>
<tr>
<td>Ba/Cd-stabilizers</td>
<td>0.27</td>
<td>0.0002</td>
<td>2.6</td>
</tr>
<tr>
<td>Pb-stabilizers</td>
<td>1.8</td>
<td>0.002</td>
<td>18</td>
</tr>
<tr>
<td>Fire retardants</td>
<td>2.3</td>
<td>0</td>
<td>22</td>
</tr>
</tbody>
</table>
Recycling of materials or of risks?

The fate of Cadmium in plastic recycling

recycling product contains 73% of Cd

100 %

residue I 14 %
residue II 2 %
Sludge 1 %
residue III 10 %

CADMIUM
Expensive identification of risks

Recycling of construction materials: the case of lead
**Sources of lead in construction recyclables: concentrations**

<table>
<thead>
<tr>
<th>Material</th>
<th>Concentration (mg Pb/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor tiles</td>
<td>5.862</td>
</tr>
<tr>
<td>Wall covering</td>
<td>6.197</td>
</tr>
<tr>
<td>Asphaltbelagschichten im</td>
<td>154</td>
</tr>
<tr>
<td>Gebäude</td>
<td></td>
</tr>
<tr>
<td>Beschüttung</td>
<td>200</td>
</tr>
<tr>
<td>Betonschichten</td>
<td>34</td>
</tr>
<tr>
<td>Dachdeckung (Schwarzdeckerarbeiten)</td>
<td>199</td>
</tr>
<tr>
<td>Dachdeckung</td>
<td>16</td>
</tr>
<tr>
<td>Dachdeckung (Stahlbeton)</td>
<td>65</td>
</tr>
<tr>
<td>Estriche</td>
<td>37</td>
</tr>
<tr>
<td>Fassadenmauerwerk</td>
<td>43</td>
</tr>
<tr>
<td>Fenster und Türen</td>
<td></td>
</tr>
<tr>
<td>Fisken (Boden)</td>
<td>905</td>
</tr>
<tr>
<td>Fliesen (Boden)</td>
<td></td>
</tr>
<tr>
<td>Mauersteine (Mauerwerk)</td>
<td>16</td>
</tr>
<tr>
<td>Natursteinmauer</td>
<td>28</td>
</tr>
<tr>
<td>Putze und Putztüraus</td>
<td>67</td>
</tr>
<tr>
<td>Wandbeläge in Innenräumen</td>
<td>7</td>
</tr>
</tbody>
</table>

**Lead concentrations in cw**
Sources of lead in construction recyclables: loadings

<table>
<thead>
<tr>
<th>Material</th>
<th>Lead Loadings (kg Pb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filling material</td>
<td>141</td>
</tr>
<tr>
<td>Brick walls</td>
<td>107</td>
</tr>
</tbody>
</table>

Lead loadings in cw
Urban mining - where are the recyclables?

Vienna stock in use and hybernating

<table>
<thead>
<tr>
<th></th>
<th>Lead [kg/capita]</th>
<th>Iron [kg/capita]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>200</td>
<td>5,000</td>
</tr>
</tbody>
</table>

Stock in Vienna landfills

<table>
<thead>
<tr>
<th></th>
<th>Lead [kg/capita]</th>
<th>Iron [kg/capita]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
<td>350</td>
</tr>
</tbody>
</table>

Source: R. Obernosterer et al, 1998
What is the value of these recyclables? Ex. lead

Quelle: Lohm et al., 1998
Goals of sustainable waste management

A. Precautionary principle:
   • Waste of today’s generation may not impose any economic or ecological burden on future generations

B. Objectives:
   • Protection of men and environment
   • Resource conservation (materials, energy, space)
   • Free of after-care (-> sustainability)

EU Strategy to reach the goals:
   Prevention, recycling, disposal (hierarchy)
New requirements for sustainable waste management

**Storage processes as sinks:**
- surface water -> oceans -> sediments
- atmosphere
- soil & lithosphere

**Transformation processes as sinks:**
- natural transformations (e.g. mineralization)
- anthropogenic transformations (e.g. thermal, biochemical)

**Clean cycles:**
- how to remove hazards from cycles?
- where to dispose of these hazardous residues -> final sinks
Financial means for sustainable waste management

Cost for:
- Collection & transport
- Treatment
- Disposal

**Dhaka**
- 0.7 €/capita year
- 0.2% GDP

**Damascus**
- 3.8 €/capita year
- 0.3% GDP

**Vienna**
- 106 €/capita year
- 0.4% of GDP

Source: Brunner & Fellner
Conclusions

- Sustainable economies require final sinks

- At present: - some sinks are overloaded
  - sink capacities are not taken into account

- WM key interface between anthroposphere and environment
  - wm must supply necessary sink capacity

- Landfills as controlled „final sinks“ are a key issue of wm

- Priority of recycling: *clean cycles and risk reduction*
Vienna, the new global headquarter of ISWA

Thank you