Urban Metabolism and Waste Management

Paul H. Brunner
Vienna University of Technology, Austria
The last 100 years: unprecedented growth in materials ...

Germany 1920

Japan 2010
... and energy flows!

England 1840

China 2010
Large and growing material stocks
Today’s stocks are tomorrow’s wastes

Example of construction materials in a growing economy

Today: ~ 5 t/c.y

in 40 years: ~ 15 t/c.y

3x
### Household metabolism: Key activities and material flows

<table>
<thead>
<tr>
<th>Activity</th>
<th>Input ([t/c.y])</th>
<th>Output ([t/c.y])</th>
<th>Stock ([t/c])</th>
</tr>
</thead>
<tbody>
<tr>
<td>To nourish</td>
<td>5,7</td>
<td>0,9 4,7 0,1</td>
<td>&lt; 0,1</td>
</tr>
<tr>
<td>To clean</td>
<td>60</td>
<td>60 0 0,02</td>
<td>0,1</td>
</tr>
<tr>
<td>To reside</td>
<td>10</td>
<td>0 7,6 1</td>
<td>100 + 1</td>
</tr>
<tr>
<td>To transport</td>
<td>10</td>
<td>0 6 1,6</td>
<td>160 + 2</td>
</tr>
<tr>
<td>Total</td>
<td>86</td>
<td>61 19 2,7</td>
<td>260 + 3</td>
</tr>
</tbody>
</table>

Material flows into stocks equal the amount of solid residues
Urban metabolism: the case of Vienna

\[ \Sigma \text{Input} \sim 200 \, \text{t/c.y} \]

\[ \Sigma \text{Output} \sim 195 \, \text{t/c.y} \]

Fluxes [t/(c.yr)]

Stocks [t]

Source: Daxbeck et al. 1996 (updated)
Abundance of “holes” - or scarcity of landfill space?
- the “substance” problem!
The stock – our future resource *(the case of iron)*

[10^6 tons]

- **primary production**
- **production**
- **consmption**
- **waste management**
- **pedo-/lithosphere**
- **other disposal**

**Geogenic iron reserve**

- 140
- 40
- 0

**Anthropogenic iron stock**

- 44
- 194
- 344

**Anthropogenic iron stock**

- 44
- 194
- 344
Goals and principles of waste management

General and global goals
- Protection of men and environment
- Resource conservation
- After care free wm: no export in time and space

Regionally appropriate means
EU: prevention – recycling – disposal
Bangla Desh: disposal – recycling - prevention

-> means depend on GDP!
Means of waste management depend on GDP

<table>
<thead>
<tr>
<th>region</th>
<th>Dhaka (GDP 450 US$/c.y)</th>
<th>Damascus (GDP 1600 US$/c.y)</th>
<th>Vienna (GDP 33’000 US$/c.y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WM costs</td>
<td>0.8</td>
<td>4.6</td>
<td>130</td>
</tr>
<tr>
<td>% of GDP</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
</tr>
</tbody>
</table>

-> Globalization of EU “waste hierarchy”?
Better waste management based on metabolism

The case of Phosphorous: how to reach the goals of wm?

Flows [kg P/c.y]

- Agriculture
- Industrial processing/distribution
- Private household
  - Agricultural wastes
  - Production wastes
  - Sewage and MSW

12/19
New design based on metabolism

Phosphorus [ % of input ]

Food

Respiration transpiration

Human body

Kitchen

Feces

Urine

Total food wastes to sewer system

Sewage

Food

Garbage

Waste

MSW treatment

100% (=0.4kg/(c.yr))

Garbage

Sewage

STP
WM decisions based on metabolism – the case of plastics

**Packaging plastic waste view**

- Consumption: 19 [kg/c.y]
- Recycling: 0
- Incineration: 2
- Landfill: 17

14 %

**Total plastic waste view**

- Consumption: 140 [kg/c.y]
- Recycling: 5 +17
- Incineration: 10 +75
- Landfill: 75

100%
Total plastic flows and stocks in Austria

Source: R. Fehringer, 1998
Additives are crucial for plastic recycling decisions

<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>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>
Metabolism needs sinks: incinerators and landfills

objectives: - mineralization of OC
- immobilization of HM

main barrier: - waste properties
additional barriers: - natural attenuation
- monitoring
Conclusions

1. Goals of wm can be reached effectively only if total metabolism is known

2. New knowledge base needed about material flows and stocks

3. Focusing on metabolism allows:
   - early recognition of future problems
   - setting priorities
   - designing effective wm systems
Vienna, where ISWA World Conference 2013 will take place

Thank you

http://mitpress.mit.edu/catalog/item/default.asp?ttype=2&tid=12806