Waste and resource management: the sink approach of Canton Zurich

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Testimonial:

„Quality ahead of Quantity: The priority for the economy of waste and resource management are clean cycles. Pollutants has to be removed und placed in safe last/final sinks.“

Prof. Dr. Paul Brunner, 2015
First Activities in Urban Mining in Canton of Zurich

Collection rate

Glas  Paper  PET  Cans (Aluminium)  Cans (steel sheet)

→ One of the leading recycling rates world wide!
**Actual new Activities in Urban Mining in Canton of Zurich**

- Reclaiming *phosphorous* from sewage sludge
- Extraction ferrous and non-ferrous metals from municipal solid waste incineration slag
- Recovery of heavy metals such as **zinc**, cadmium and lead from waste incineration filter ash
- Increasing the recycling rate of **C&D Waste** (80%)
Do we have problems with sinks?

Heavy Metals in River Water Sediment (2004-2011)

Close to 40% of investigated areas fail good conditions related to Zinc and Copper (Canton Zurich)

Questions of this study

(1) What sinks are available to accommodate waste? (Cu, Zn, PAK, brominated Diphenylethers)

(2) To what extent does economic activity fill up the capacity of these sinks, and what proportion is accounted for by the waste management sector? [Analysis]

(3) Are shortages in the sinks’ capacity for waste to be expected? [Evaluation]

(4) Might any capacity shortages be resolved by source-based and/or alternative waste management processes? [Measures]
Methodical Aspects

Material Flow Analysis (1)

- Material Flow  physical transfer of material from one process to another process

- Process:  is spatial and timely limited and part of the Equation of the Material Flow Analysis [e.g. tons/year]

Equation (process terms):

Sink = Input – Output + Source

«Sink» as a Process (Addition to stocks, Forming by Reaction (e.g. Dioxin during burning process)
Sink classification scheme (2)

- **Anthroposphere**
  - Stocks of consumer and capital goods
  - Landfills (with potential emissions)
  - Thermal treatment
  - Inert materials landfills (without aftercare)

- **Environment**
  - Atmosphere, watercourses, sediments of river impoundments, soil, glaciers
  - Underground, Lake and ocean sediments

- **Temporary** (processes with source and sink functions)
  - 0-10,000 years

- **Permanent** (processes with sink functions)
  - >10,000 years or full mineralisation
  - "Last sink"
Methodic of Assessement (3)

a) The actual flow is compared with the critical flow

b) The critical flow was derived from
   - applicable environmental law or
   - goals in the «Action plan for Waste and Resource Management, 2015-18» of Canton Zurich or
   - the description of State of the Art (AWEL Zurich)
(4) **Indikator ω** = \( \frac{\text{Actual sink capacity utilization for } i}{\text{Critical sink capacity utilization for } i} \)

The Variable \( i \) is an index for the individual flows

ω is referring to
- Goods or Selected Substances (Cu, Zn, PAH, DecaBDE)
- a certain flow to a sink
- a certain time period
Macroeconomic material flows and their accumulation or mineralisation in natural and anthropogenic sinks (5)
**Characterisation System structure (6)**
(no of Flows [F] and Processes [P])

3 sub-systems

- **Production, Usage**
  (3F & 3P)

- **Waste and Resource Management**
  (42F & 13 P)

- **Waste Water Management**
  (26F & 12P)

**Overall System 158F & 61P** (disaggregated 17 F & 9 P)
Structure of the Waste and Resource Management sub-system for copper (7)
## Results

### Selected results of “Sink capacity utilisation” for waste in 2013 (1)

<table>
<thead>
<tr>
<th>Sinks</th>
<th>Goods (mio t/yr)</th>
<th>Cu (t/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production and usage phase (sinks for recycled secondary raw materials)</td>
<td>2.5</td>
<td>7,000</td>
</tr>
<tr>
<td>Thermal waste treatment facilities</td>
<td>6.8&lt;sup&gt;1)&lt;/sup&gt;</td>
<td>1,400&lt;sup&gt;1)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Gravel quarries, landfills</td>
<td>9.9</td>
<td>1,800</td>
</tr>
<tr>
<td>Railway routes</td>
<td>80*10^-6</td>
<td>1</td>
</tr>
<tr>
<td>Unknown sinks</td>
<td>74*10^-3</td>
<td>590</td>
</tr>
<tr>
<td>Environmental media</td>
<td>2,400</td>
<td>63</td>
</tr>
<tr>
<td><strong>Total sink cap. utilisation</strong></td>
<td><strong>2,400</strong></td>
<td><strong>9,400</strong></td>
</tr>
</tbody>
</table>

1) To avoid double-counting, the indicated loads were not added to the total sink capacity utilisation
**Critical flow for Copper in slag (WIP)**

<table>
<thead>
<tr>
<th>«Critical Flow» defined by following criterium/szenarium</th>
<th>Actual Flow (t/a)</th>
<th>Crit. Flow (t/a)</th>
<th>ω</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treshold value of landfill Type E complied (actual law for other waste)</td>
<td>900</td>
<td>638</td>
<td>1.4</td>
</tr>
<tr>
<td>95% metallic Cu recovered (technical possible → expected «State of the art»)</td>
<td>900</td>
<td>473</td>
<td>1.9</td>
</tr>
<tr>
<td>Treshold value of landfill Type B complied (inertness, Swiss guiding principle)</td>
<td>900</td>
<td>64</td>
<td>14</td>
</tr>
</tbody>
</table>

The diagram shows the critical range, sub-critical range, and non-critical range for residual copper in treated slag.
The Sink Approach, Zurich
«Thermorecycling» (ZAV-Recycling AG Hinwil): slag treatment processes

ZAR (foundation)
Development Center for sustainable management of waste recycling
Clean Circle & functional Recycling

e.g. Copper in iron metals from slags

<table>
<thead>
<tr>
<th>Improvement with state of the art</th>
<th>Actual Flow (t/a)</th>
<th>Critical Flow (t/a)</th>
<th>$\omega$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper in iron metals from slag (WIP)</td>
<td>220</td>
<td>110</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Indikator $\omega$

- Critical Range
- Sub-Critical Range
- Non-Critical Range
Cupper extraction from extracted iron
Conclusions: in general

1) The need for anthropogenic and natural sinks is enormous, at 13 t/yr *capita.

2) Problematic substances should be channelled out to maintain high-quality cycles.

3) The metal industry determines the requirements to metallic raw materials (quality, impurities) → non functional recycling.

4) Gravel Quarries and landfills provide suitable sinks for inorganic mineral waste with immobile substances (inertness, final sinks).

5) The capacity and condition of the (limited) natural sinks must be monitored, and early measures must be taken to prevent any capacity shortages.
Urban Mining \[\leftrightarrow\] intact sinks
Future Activities in Urban Mining in Canton of Zurich

Substance dossiers

Potential Analysis Urban Mining
Challenge 2: Exported from Canton Zurich to underground facilities (tons)

- Ash from electrical filter systems
- Other hazard wastes
- Other FGCR

FGCR = Flue Gas Cleaning Residues
Resolving capacity shortages referring to Copper

<table>
<thead>
<tr>
<th>Material</th>
<th>Proposed measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>WIP slag</td>
<td>Fixing a goal of 95% for the recovery of metallic copper from the WIP slag</td>
</tr>
<tr>
<td>WIP scrap</td>
<td>Support for activities to remove Cu from WIP scrap. The Centre for the Sustainable Ressource Management of Waste (ZAR) is currently conducting research and development to identify the potential for regaining Cu.</td>
</tr>
</tbody>
</table>
Conclusions: specific

1. Soil and partially also river sediments are receiving critical loads of copper

2. The release to the environment of copper by the waste management is not higher than by production/use and waste water management

3. Thermal treatment plants provide appropriate sinks for organic pollutants. 4% of PACs and 85% of DecaBDE were destroyed.

4. Substantial resource losses by i) exports of materials ii) depositing on quarries and landfills and iii) non functional usage

5. Measures to improve are described (see also «Action plan for Waste and Resource Management, 2015-18» of Canton Zurich and the new Swiss Ordinance on waste management).