Sinks as integrative elements of the anthropogenic metabolism

Ulrich Kral, Paul H. Brunner
Vienna University of Technology

Problem:
Sink loads pose risks for human & environmental health.
**Scope:** Setting the scope of the assessment includes the selection of a substance, a reference region and a period of interest.
**Inventory:** It results the actual sink load in mass per time. First, the tool substance flow analysis (SFA) is applied to investigate regional substance flows. The software STAN is used for data reconciliation and error propagation in order to balance flows and stocks. Third, Sankey-diagrams are elaborated to present SFA results. Fourth, actual flows to sinks are summed up to result the actual sink load.

**Copper in Vienna 2008**

- **Actual sink load:** 1,128 t/a

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Impact assessment: It results the acceptable sink load in mass per time. First, normative criteria (NC) and reference values are defined along the cause-effect chain. Criteria are derived from goal oriented frameworks with respect to waste and emissions such as regulations. Second, each actual flow is varied as long as the reference value is achieved, resulting the critical flow. Third, acceptable flows are determined and summed up to result the acceptable sink load.
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### Lead in Vienna 200

- **Actual flow:** 191 t Pb/a into sinks
- **Landfill**
  - 144 t/a
  - 233 t/a
  - 123 t/a
- **Underground storage**
  - 44 t/a
  - 44 t/a
- **Air**
  - 1.6 t/a
  - 6.1 t/a
  - 1.6 t/a
- **Water**
  - 0.6 t/a
  - 0.6 t/a
  - 0.6 t/a
- **Soil**
  - 1 t/a
  - 1 t/a
  - 1 t/a

**Acceptable sink load:** 176 t/a

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**Inventory** → **Impact assessment** → **Indicator score**

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**Cu Pb PFOS**
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PFOS in Switzerland 2006

<table>
<thead>
<tr>
<th>Source</th>
<th>Actual Flow</th>
<th>Critical Flow</th>
<th>Acceptable Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incinerator</td>
<td>2.26 t PFOS/a into sinks</td>
<td>1.74 t/a</td>
<td>0.48 t/a</td>
</tr>
<tr>
<td>Water</td>
<td>1.74 t/a</td>
<td>0.74 t/a</td>
<td>0.42 t/a</td>
</tr>
<tr>
<td>Soil</td>
<td>0.03 t/a</td>
<td>- t/a</td>
<td>- t/a</td>
</tr>
<tr>
<td>Landfill</td>
<td>0.09 t/a</td>
<td>- t/a</td>
<td>- t/a</td>
</tr>
<tr>
<td>Air</td>
<td>&lt;0.01 t/a</td>
<td>- t/a</td>
<td>- t/a</td>
</tr>
</tbody>
</table>

Acceptable sink load: 2.17 t/a
A new indicator... 
...with respect to sink limitation

We propose to use a single score indicator $\lambda$ on a substance specific base. It quantifies the environmental acceptable share of a substance to sink processes. It ranges from 0% to 100%. Either all actual flows are fulfilling criteria of acceptability ($\lambda = 100\%$) or at least one flow is unacceptable ($0\% < \lambda < 100\%$).

$$\lambda = \frac{\text{Acceptable sink load}}{\text{Actual sink load}} \times 100$$

Copper in Vienna 2008

$\lambda = 99\%$

Measures to increase the indicator score:
- Elaborating legal limits for heavy metals in urban soils
- Monitoring loads to urban soil and river Danube
- Reducing airborne emissions
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$$\lambda = \frac{\text{Acceptable sink load}}{\text{Actual sink load}} \times 100$$

Lead in Vienna 2008

$\lambda = 92\%$

Measures to increase the indicator score:
- Optimizing recycling rates
- Expanding landfill capacities
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$$\lambda = \frac{\text{Acceptable sink load}}{\text{Actual sink load}} \times 100$$

PFOS in Switzerland 2006

$\lambda = 96\%$

Measures to increase the indicator score:
- Managing the stockpiles
- Minimize and eliminate emissions
- Conducting research regarding the cause of PFOS generation in waste water treatment plants