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Waste treatment

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With contributions by Gabor Doka

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- Scope/System boundaries
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Waste Side Story

- Disposal is as much a part of the life cycle as production
- A direct valuation of wastes per kilogram is too coarse: it neglects any differences in composition
- Disposal processes produce waste material outputs themselves. Their further downstream fate has to be inventoried too.

Goals of the Study:

- *Waste-specific* inventories, that heed composition
- *Complete Assessment* of the fate of all waste outputs
- Based on existing studies at ETH: Zimmermann *et al.*1996, Hellweg 2000, Doka 2000

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Scope

- Waste inventories shall assist the inventories of production in ecoinvent 2000 (**background processes**)
- This is *not* a study on options or strategies in waste management, but shall inventory **present disposal practices**.
- Disposal **practices of Switzerland** are inventoried. The developed models are also used for similar processes abroad.
- No recycling processes are inventoried here (see production).
- MS Excel-Tools for the user allow calculation of own waste-specific inventories and are part of the ecoinvent v1.0 documentation published approx. February 2004 on CD-ROM.

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Inventoried Systems

- Municipal waste incineration KVA/MSWI
- Hazardous waste incineration SAVA/HWI

incineration (part II)

- Sanitary landfill* (untreated municipal waste)
  * for burnable waste prohibited in Switzerland since 2000.
- Slag compartment for MSWI bottom as
- Residual material landfill (inorganic waste)
- Inert material landfill (inert construction waste + clean excavation)
- Underground deposits UTD in salt mines (no nuclear waste)

landfills (part III)

- Landspreading/Landfarming **(part III)**
- Municipal wastewater treatment ARA/WWTP **(part IV)**
- Building demolition & disposal options incl. sorting **(part V)**

(report parts)

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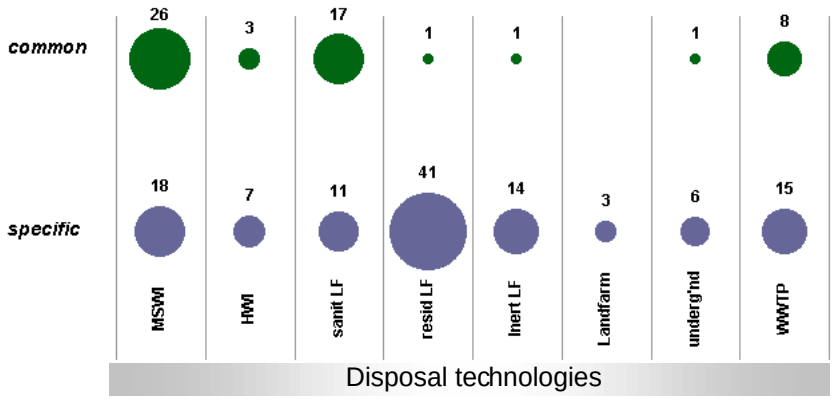
Number of different inventoried wastes

- Common wastes (e.g. packaging) and
- Specific wastes from production processes (z.B. waste from car manufacture)



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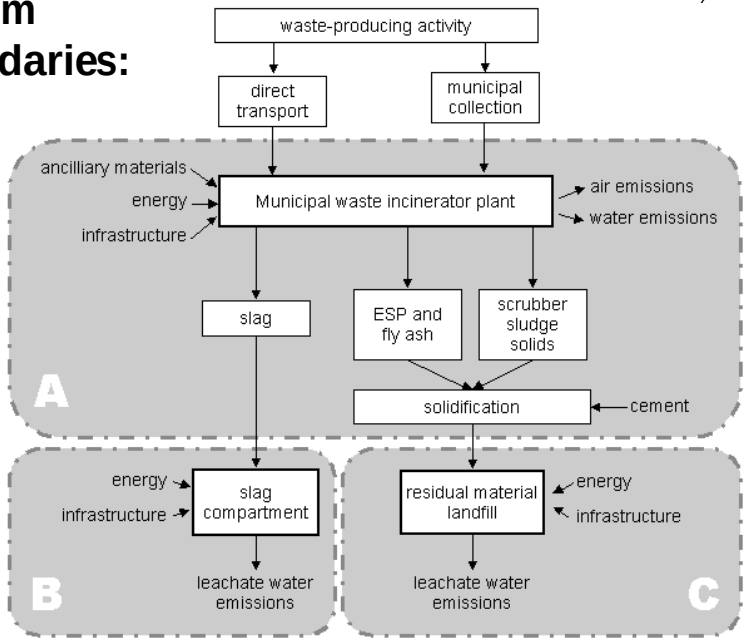
System boundaries: MSWI



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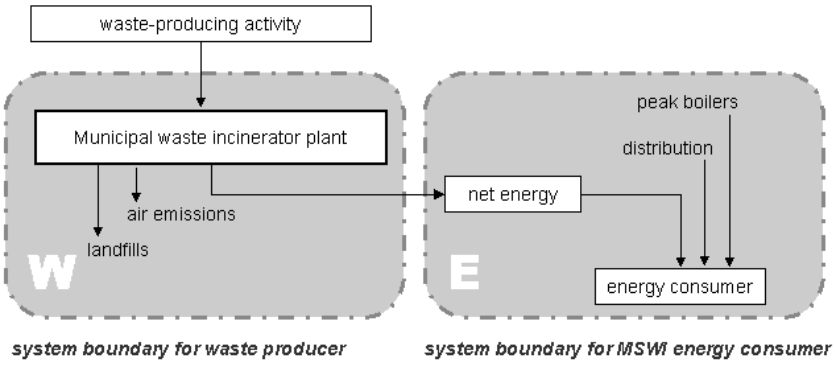
Allocation Energy: example MSWI

- Energy production is but a small share of the revenues in a MSWI
- All burdens of MSWI are allocated to the service function 'waste disposal'
- The *consumer* of MSWI energy receives a very unburdened energy



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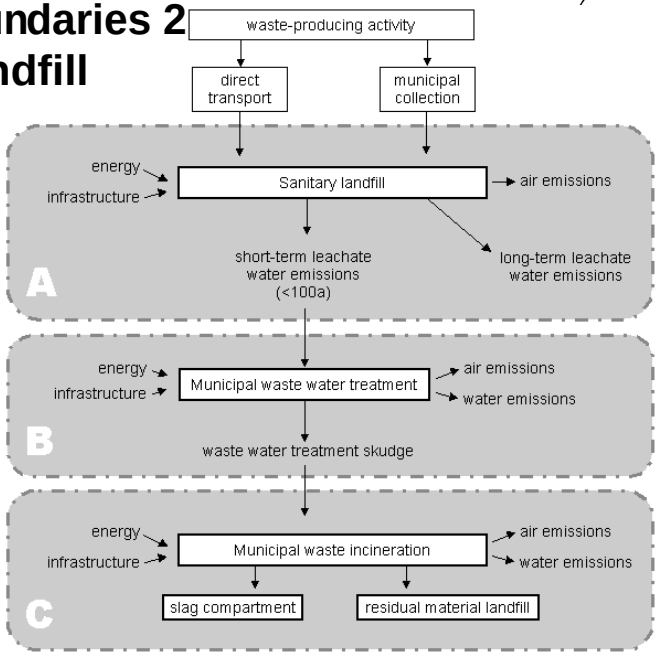
System boundaries 2 Sanitary landfill

The complete calculation of the emissions of the sanitary landfill needs **5 different disposal models**



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System boundaries 3: building wastes

Inventories of building material disposal include the **demolition of the building.**

Demolition energies and emissions (PM) are inventoried.

Three options of disposal are distinguished:

1. Directly to Recycling
2. Disposal via sorting plant (partial recycling if possible)
3. Direct disposal without material recycling (e.g. burnables)

→ application according to construction type and/or local situation

Sieved fine fraction from sorting plant is landfilled (here in sanitary landfill)

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Framework of waste-specific inventories

- *Waste-specific burdens:*
  depend on the waste composition
- *Process-specific burdens:*
  independent of the waste composition
- Behaviour of chemical elements is modelled using transfer coefficients (no compounds).
- The waste-specific output (emission or secondary waste) of a disposal plant is modelled with
  Output = composition times transfer coefficient
  consistently for 41 chemical elements (formerly only 8 to 23).
- I.e. if a waste contains no lead, no direct lead emissions will be inventoried for that waste.

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Compositions & choice of disposal type

- Waste compositions from literature sources or manufacturer data
- Assessment gaps for 41 elements are frequent
- Choice of disposal type according to manufacturer information or based on material characteristics
  „to landfill" → often to residual landfill
  „Ablagerung"→ landfill? intermediate storage? underground storage?
- Many disposal practices are possible, which are prohibited in Switzerland (Landfarming, burnables to sanitary landfill)

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Waste-specific landfill model

- The landfill model consists chiefly of transfer coefficients for different chemical elements
- Formerly results from **short-range laboratory tests** were used to estimate the leaching of pollutants (Zimmermann et al. 1996, Hellweg 2000, Doka 2000)
- The principle of "limited leaching" contradicts findings of landfill researchers, that express a principle of **unlimited geochemical weathering given enough time** (e.g. Annette Johnson EAWAG; Peter Lechner & Thomas Sabbas, BOKU Vienna)
- The new landfill models are based on literature data of **landfill leachate emissions measured on site**.

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Waste-specific landfill model 2

- The expected developments of the landfill are heeded:
- Development of carbonate buffer and pH influences the solubility of different phases and elements
- Oxianions are soluble at high, alkaline pH (e.g. Cr, As, Mo, V, B, W, Se, Sb)
- Other metals are soluble at low, acidic pH (Zn, Cu, Pb, Cd, Hg, etc.)
- Precipitation, intrusion and preferential flow paths influence the speed of weathering and leaching from the landfill.
- Re-precipitations within the landfill are heeded.
- In sanitary landfills: the degradabilities of different waste materials is heeded

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Waste-specific landfill model 3

The calculated landfill emissions are discerned into two categories:

- **Short-term emissions (ST) zero to 100 years** after waste placement
- **Long-term emissions (LT) more than 100 years** after waste placement

The model calculates the emissions up to the **next midland-covering iceage** (estim. 60'000 years) as a **mean value**.

As **maximal value** of the uncertainty assessment a **complete weathering and emission** is assumed (except chromite).

Pro Memoria: In life cycle inventories emissions are given **irrespective of place, time or concentration** (ISO 14'042)

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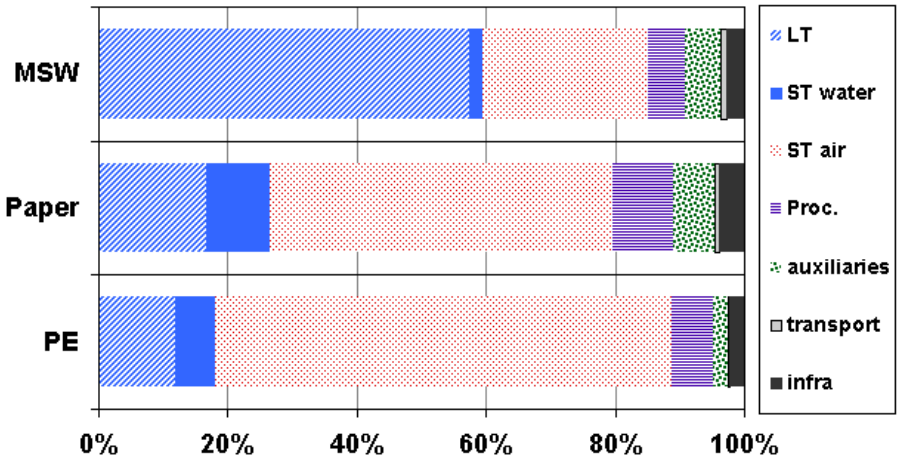
Results: contributions MSWI

- Incineration in MSWI of municipal waste, paper, or polyethylene (valuation with Eco-indicator'99 HA)



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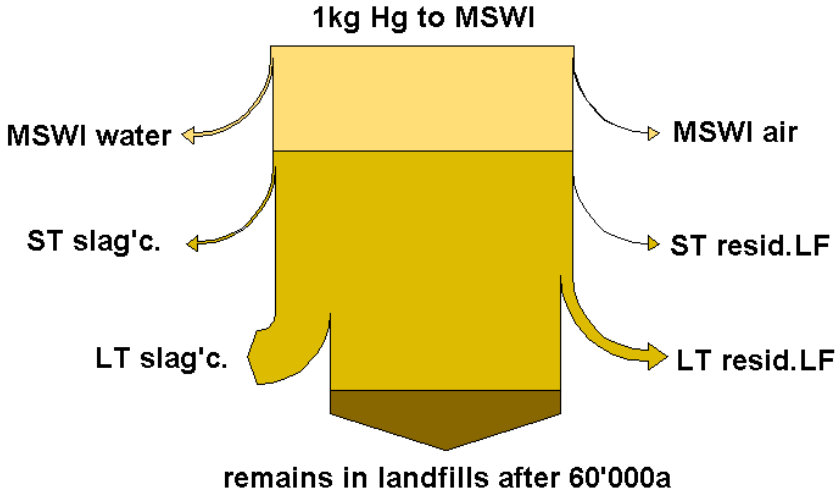
Results: Sankey diagramm

Distribution of 1kg of mercury in the complete MSWI process (average municipal waste)



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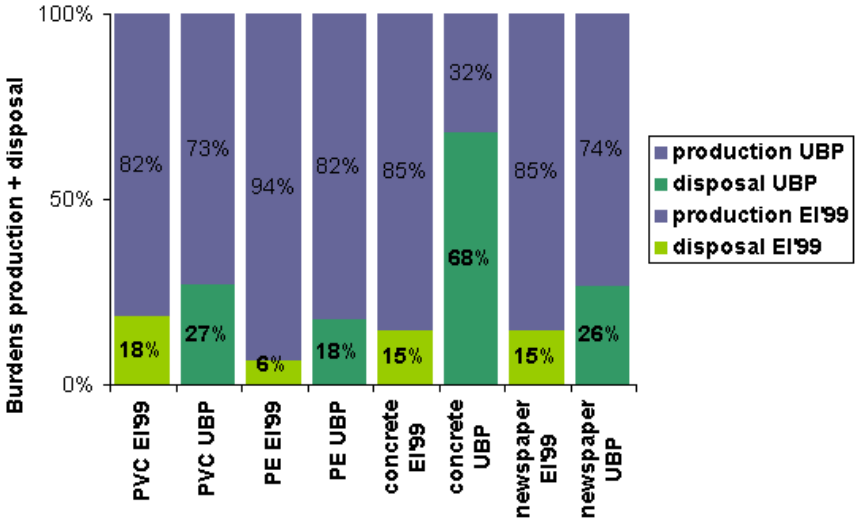
Relevance of disposal in the life cycle

- Contribution of disposal to the life cycle (EI'99 HA and UBP'97)



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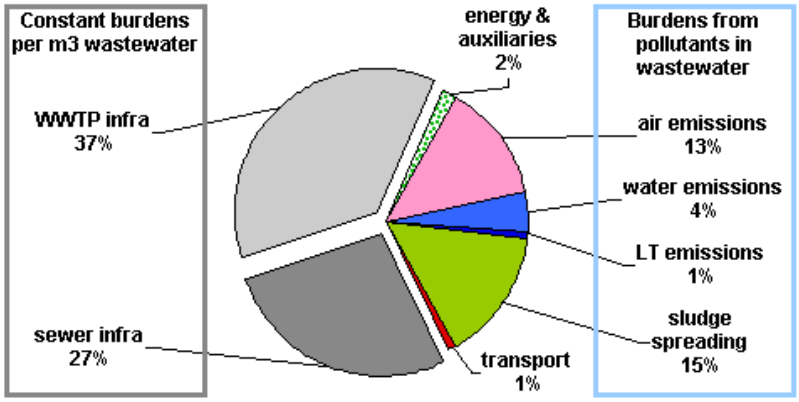
Results: contributions WWTP

- Treatment of 1m³ of average wastewater
  in a WWTP of capacity class 3 (valuation with Eco-indicator'99 HA)



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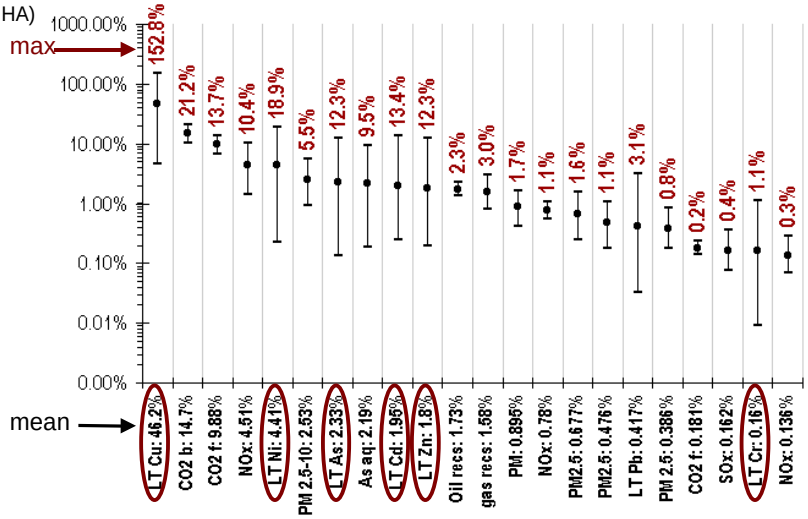
Results uncertainty

Valuated cumulated exchanges and their cumulated uncertainties for avg. waste to MSWI in decreasing contribution (valuation with Eco-indicator'99 HA)



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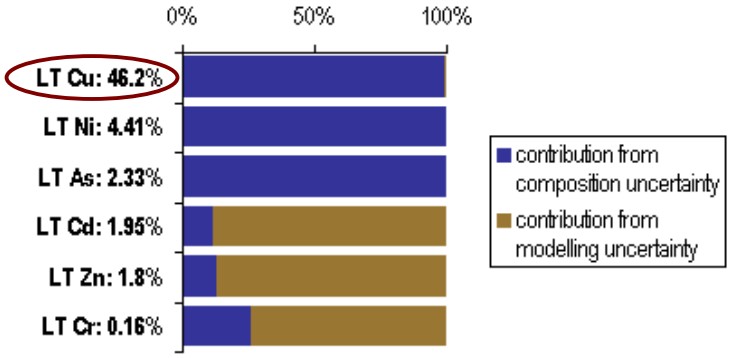
Results uncertainty 1

What are the main contributions to uncertainty?

1. Variability of waste composition
2. Variability of models (MSWI and landfills)



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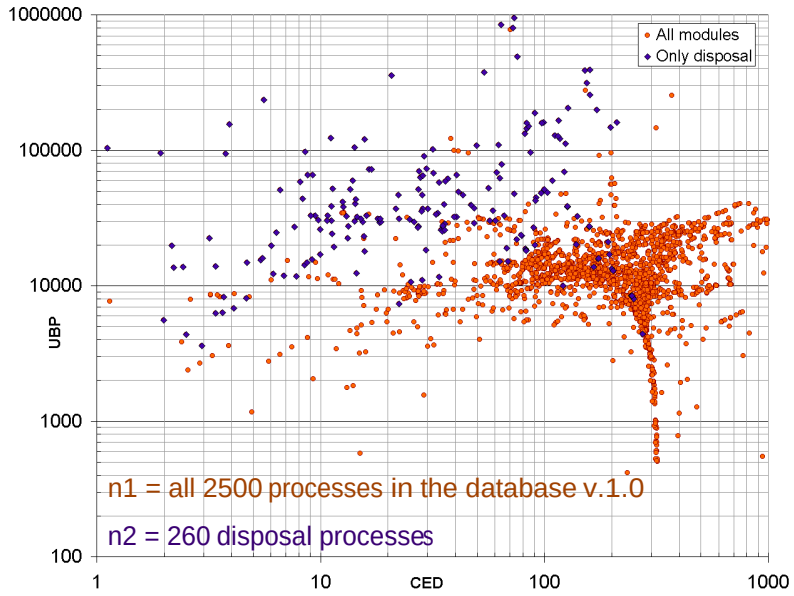
Folie 21 "Life Cycle Inventories of Waste Treatment Services" G. Doka, Dec. 2003

Results: correlation CED vs. UBP

Is there any correlation between primary energy demand CED and environmental burden UBP'97*?

The answer is ‚No'!

* UBP'97 is the environmental scarcity method



Folie 22 "Life Cycle Inventories of Waste Treatment Services" G. Doka, Dec. 2003

Conclusions

- Disposal is a relevant part of LCA
- Waste-specific modelling of disposal is complex
- ecoinvent-user tools for waste-specific modelling are available
- Disposal technologies and pathways of production wastes should be inventoried in same detail as the production inputs themselves
- Valuation issues are decisive (LT) and can lead to controversy

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Possible future work

- Models for mining tailings and acid rock drainage
- Convergence of concepts and methodologies of landfill models and LCIA models for pollutant fate in soil
- Disposal technologies in less developed countries
- Models also for chemical compounds, not only chemical elements
- More complete and more representative waste compositions

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