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Waste treatment

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Folie 1

“Life Cycle Inventories of Waste Treatment Services” G. Doka, Dec. 2003



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Contents

- Introduction/Goal
- Systems
- Scope/System boundaries
- Allocation (example MSWI)
- Waste-specific modelling (example landfills)
- Some results
- Possible future work

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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
 - 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)
 - Landspreading/Landfarming
 - Municipal wastewater treatment ARA/WWTP
 - Building demolition & disposal options incl. sorting
- incineration (part II)
landfills (part III)
(part III)
(part IV)
(part V)
(report parts)

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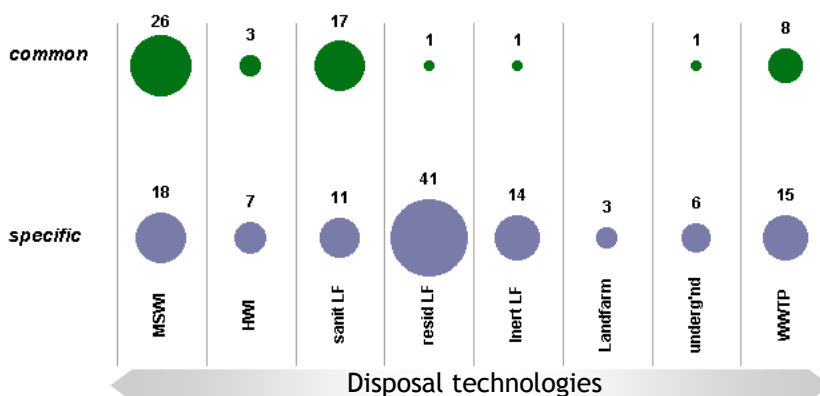


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Number of different inventoried wastes

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




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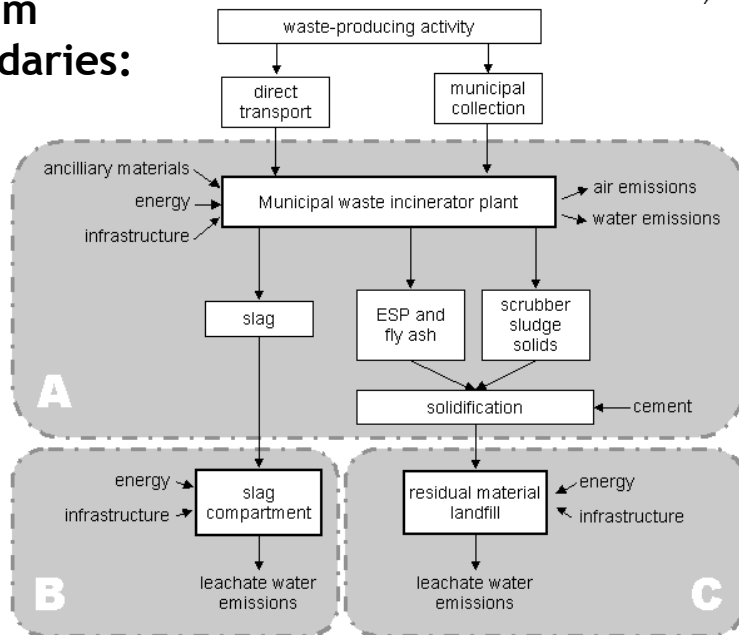
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System boundaries: MSWI



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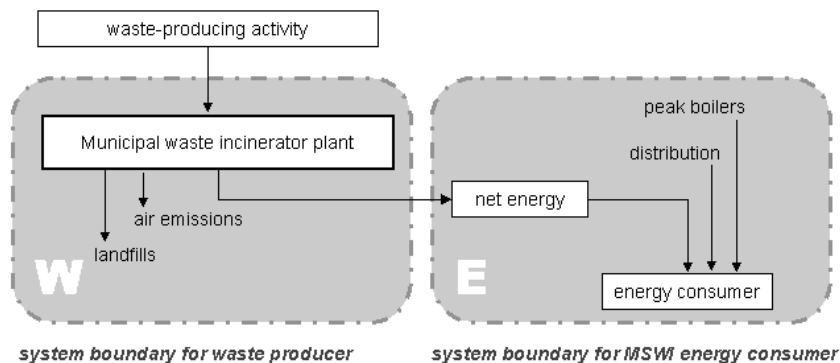
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Allocation Energy: example MSWI

- 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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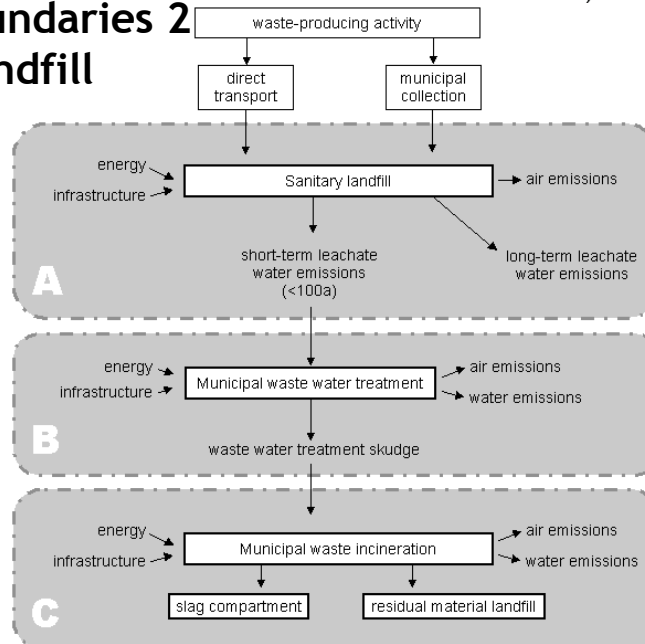
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System boundaries 2 Sanitary landfill

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

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- *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

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- 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

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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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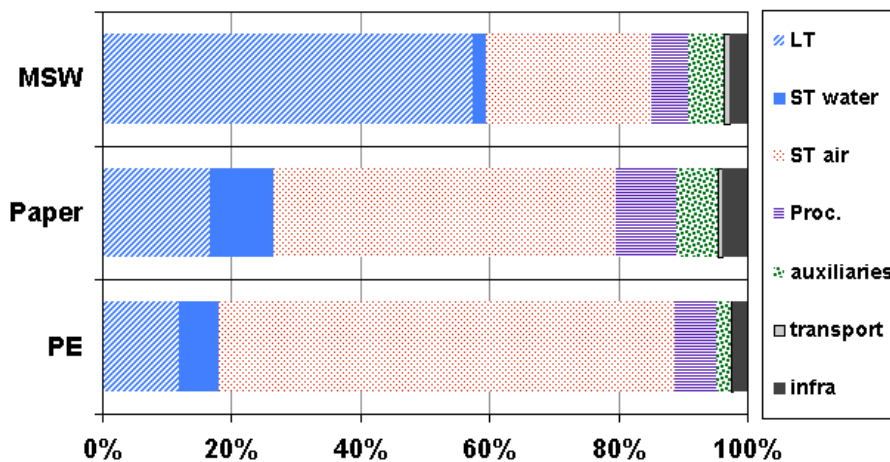
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Results: contributions MSWI



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



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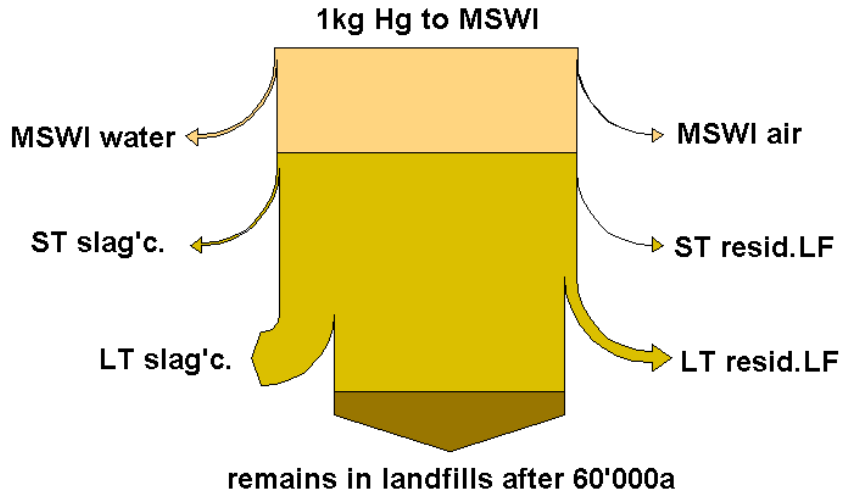


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Results: Sankey diagramm

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



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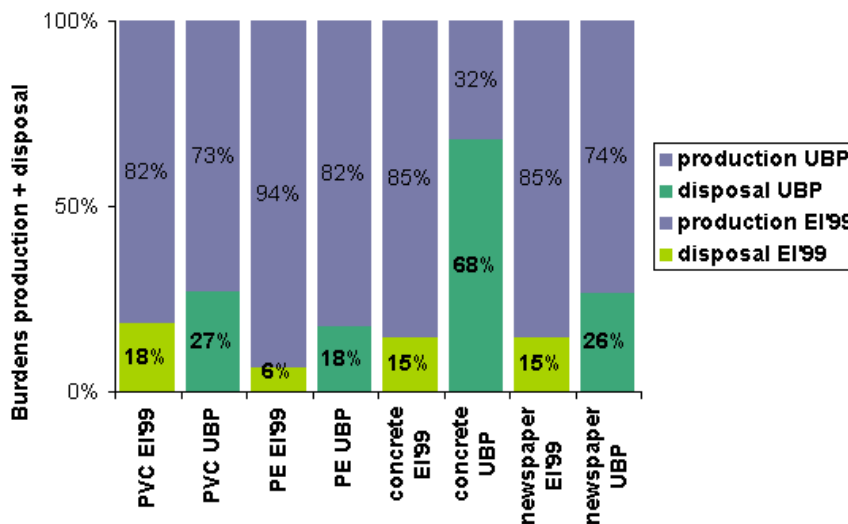


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Relevance of disposal in the life cycle

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



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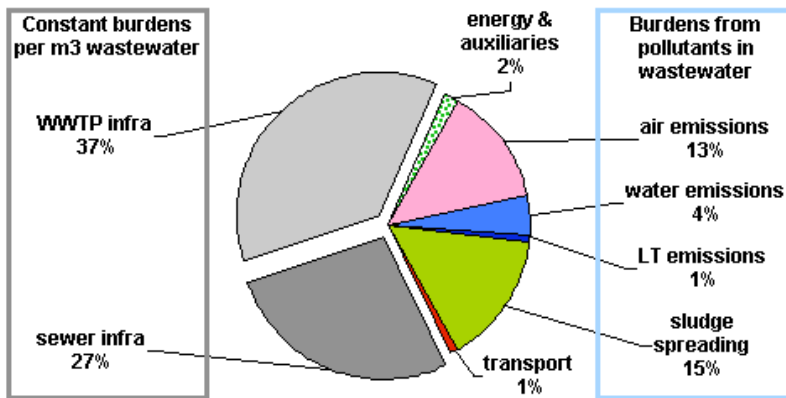


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Results: contributions WWTP

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



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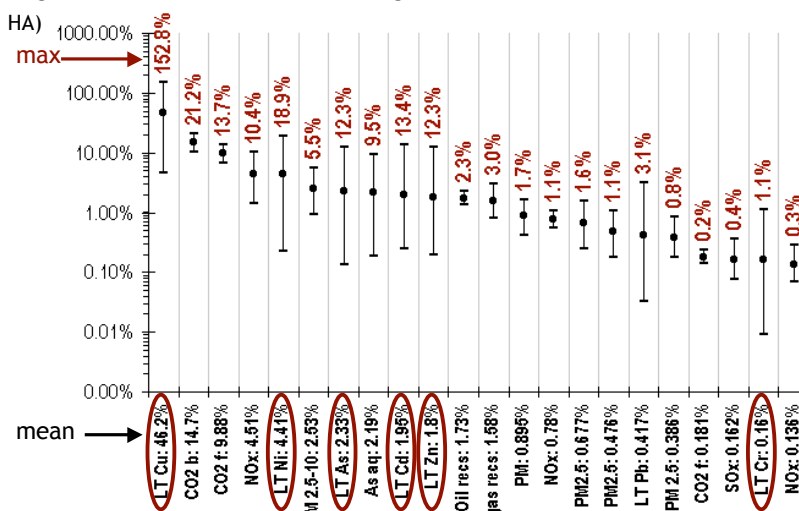
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Results uncertainty

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



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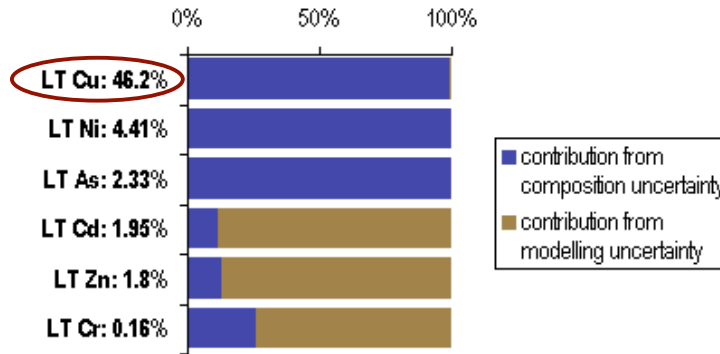
Results uncertainty 1



What are the main contributions to uncertainty?

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

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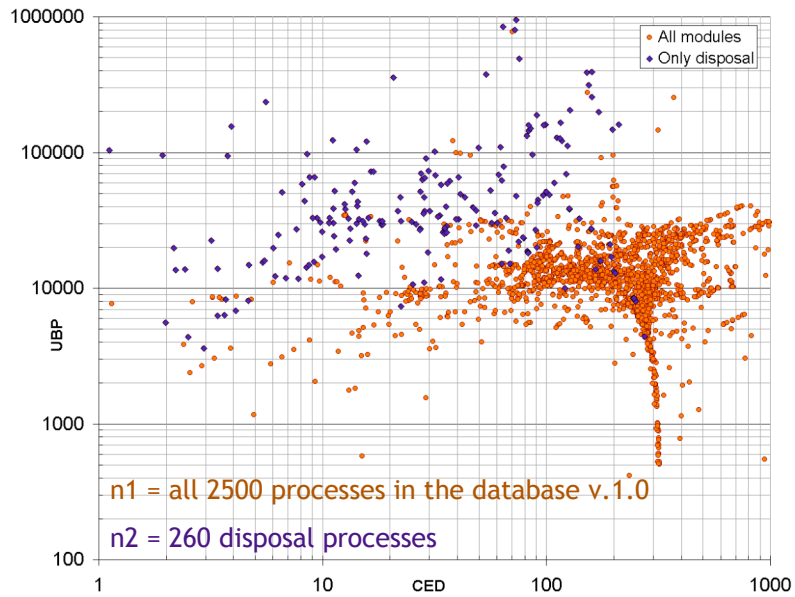
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Results: correlation CED vs. UBP

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



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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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