23.04.2012

LCA of biomass treatment

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Contents

- Update of ecoinvent data
- GHG-emissions from treatment, workshop May 2011 in Baden

- Effects of accounting organic matter in compost and digestate
  - organic matter
  - ecoinvent processes

- Influence of heavy metals on evaluating biomass treatment
  - Impact assessment: single score, midpoint methods
  - Uncertainty in toxicity and LCA
  - Including benefits of organic matter
  - ecoinvent processes

- Conclusions

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Goal of the study

To answer the following questions:

- What is the best treatment of biowaste?
- Which emissions are relevant in the processes?
- How do the results change based on the properties and the components of the biowaste?

Check and revise ecoinvent data

Studied systems

Composting

Anaerobic digestion

Municipal Waste Incineration

Functional unit

Treatment of 1 ton biowaste

System boundaries

Environmental impact of treatment processes

Benefit for energy production and fertiliser substitution

Specific questions to be answered or tasks to be fulfilled

- Revise the existing emission data in ecoinvent
  ⇒**Workshop** on the latest measurements
- Evaluating the benefits of the product and by-products of the different treatments
  ⇒evaluating the value of **organic matter in LCA**
- Determine and revise the dominant factors for the results
  ⇒Influence of **heavy metals** on evaluating biomass treatment
- Interpretation of the results
  ⇒conclusions
  ⇒ecoinvent processes

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Workshop GHG-emissions

ecoinventories of biowaste valorisation

Inhalt	Referent
Einleitendes Referat mit den bisherigen Zahlen in Ökobilanzen	Konrad Schleiss + Mischa Zschokke
Messergebnisse bei Hausgarten- und Kleinmietenkompostierung	Florian Amlinger
Messergebnisse bei Grosskompostierungen und Vergärungsanlagen	Carsten Cuhls + Joachim Clemens
Emissionszahlen aus der Schweiz/ Biogasforum	Hans Engeli + W. Edelmann
Messergebnisse bei EPDM-Gasspeichern bei landw. Biogasanlagen	Elmar Büeler
CH_4-Emissionen aus der Aufbereitung von Biogas, alte und neue Erkenntnisse	Urs Baier
CH_4-Emissionen aus der Aufbereitung von Biogas, Ergebnisse mit der Aminwäsche	Marc Zysset
Emissionszahlen von Kompogasanlagen	Bernhard Wanner
Workshop am Nachmittag in 3 Gruppen	Teilnehmer
Gruppe 1: Emissionen aus Sammlung, Transport, Lagerung und biologischem Prozess (nach verschiedenen Verfahren aufgeschlüsselt)	Carsten Cuhls, Seraina Steinlin, Rainer Kegel, Alina Soltermann, Mischa Zschokke, Hans Engeli, Helmut Vetter
Gruppe 2: Methan- und Lachgasemissionen von Nachgärung, Lagerung, Separation, Ausbringung inkl. den Aspekten der organischen Substanz in den Produkten	Florian Amlinger, Simon Bolli, Joachim Clemens, Konrad Schleiss, Bruno Guggisberg, Werner Edelmann, Bernhard Wanner
Gruppe 3: Methanemissionen bei Gaslagerung, BHKW, Gasaufbereitung und –einspeisung ins Gasnetz Vergleich zu Emissionen im Gasnetz	Marc Zysset, Tim Hermann Elmar Büeler, Urs Baier Bruno Götz, Fabian Ruoss, Elmar Kuhn
Abschluss des Workshops	Rolf Wagner

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Workshop GHG and other emissions

Presentation of the latest measurements in Switzerland and Europe concerning the emissions of the following systems:

- Private composting
- Windrow or industrial composting
- Anaerobic digestion
- Postcomposting of digestate
- Agricultural Co-digestion
- Upgrading of biogas

Discussing the measurements with about 25 experts from Switzerland and neighbour countries.
Estimate the effective emission quantities based on the latest results.

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Results I

Table 3: Synthesis for Composting – Converted to CO_2-equivalents per kg FM

Emissions [g]/kg FM	Transport / Pre-treatment	Average	Biological Process	Average	Total
	[g]	in [g] CO_2	[g]	in [g] CO_2	in [g] CO_2
CH_4, biogenic	0.01-0.1	1.25	0.5-1.5	25.00	26.25
CO_2, biogenic			260.00		
CO_2, fossil	4 - 13	10.00	2 - 10	7.80	17.80
N_2O		0.00	max 0.05	14.90	14.90
Total		11		48	**59**

Note: methane emissions were overestimated by about 5 times in the earlier version of ecoinvent

Ammonia, N_2O and methane are most important for LCA

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Results II

Table 4: Synthesis for Ananerobic Digestion – Conversion to in CO_2-equivalents per kg FM

Emissions [g] / kg FM		Pre-storage	Avr.	AD Process	Avr.	Storage/ Post-comp.	Avr.	CHP	Avr.	Gas condition-ning	Avr.	Total
		[g]	in [g] CO_2	[g]	in [g] CO_2	[g]	in [g] CO_2	[g]	in [g] CO_2	[g]	in [g] CO_2	in [g] CO_2
	CH_4, biogenic	<= 0.1	1.25	0.5-0.8	15.00	1-2.5	37.50	0.5-1.5	25.00	0.1-1.5	12.50	78.75
	CO_2, biogenic			260.00								
	CO_2, fossil	4 - 13	10.00	2.60	2.60		2.60					15.20
	N_2O	0-0.010	2.98	0-0.010	14.90		14.90					32.78
	Total		14		32		55		25		12	**126**

Note: methane emissions were overestimated by about 5 times in the earlier version of ecoinvent

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Organic matter in compost and digestate

- Organic matter is a major component of biowaste
- If biowaste is incinerated, 100% of organic matter is mineralized and a high amount of energy from organic matter can be recovered
- In biological treatment such as composting or anaerobic digestion, only about 50% of the organic matter is degraded on average
- So the question arise: What is the value of the remaining organic matter in compost or digestate ?

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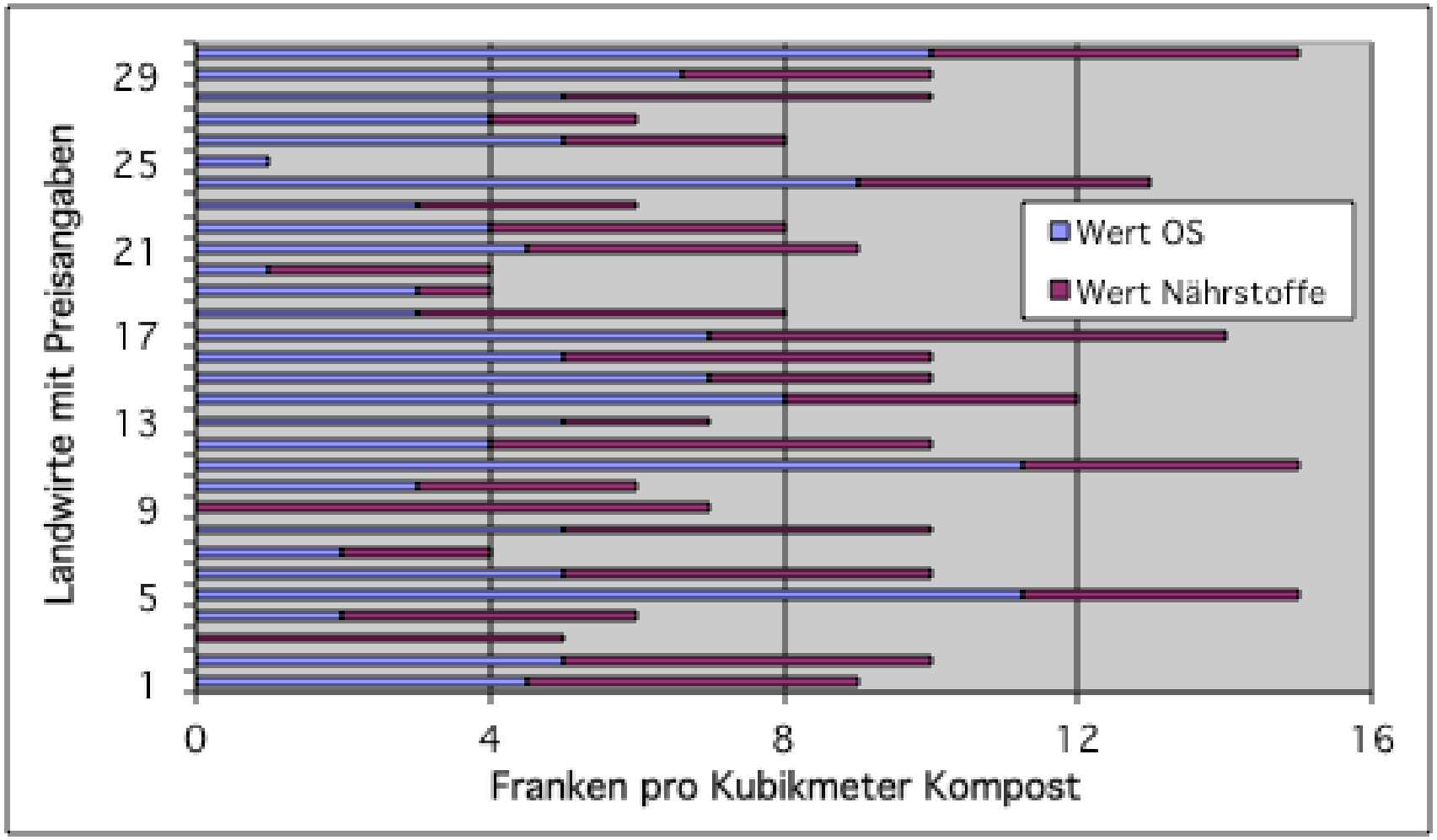
Farmers estimations on the value of compost

Organic matter in compost and digestate

Estimations of the value of compost, for its fertilising elements and its organic matter



Farmers give it more value than to the fertilising part of compost

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Evaluating the value of organic matter

How to improve organic matter content in the soil, if no compost is available:

- Farmers normally use straw. In Switzerland straw is imported.
- In horticulture imported peat is used.

So we calculated the value by substitution products like straw and peat.

This approach has been discussed with national and international experts.

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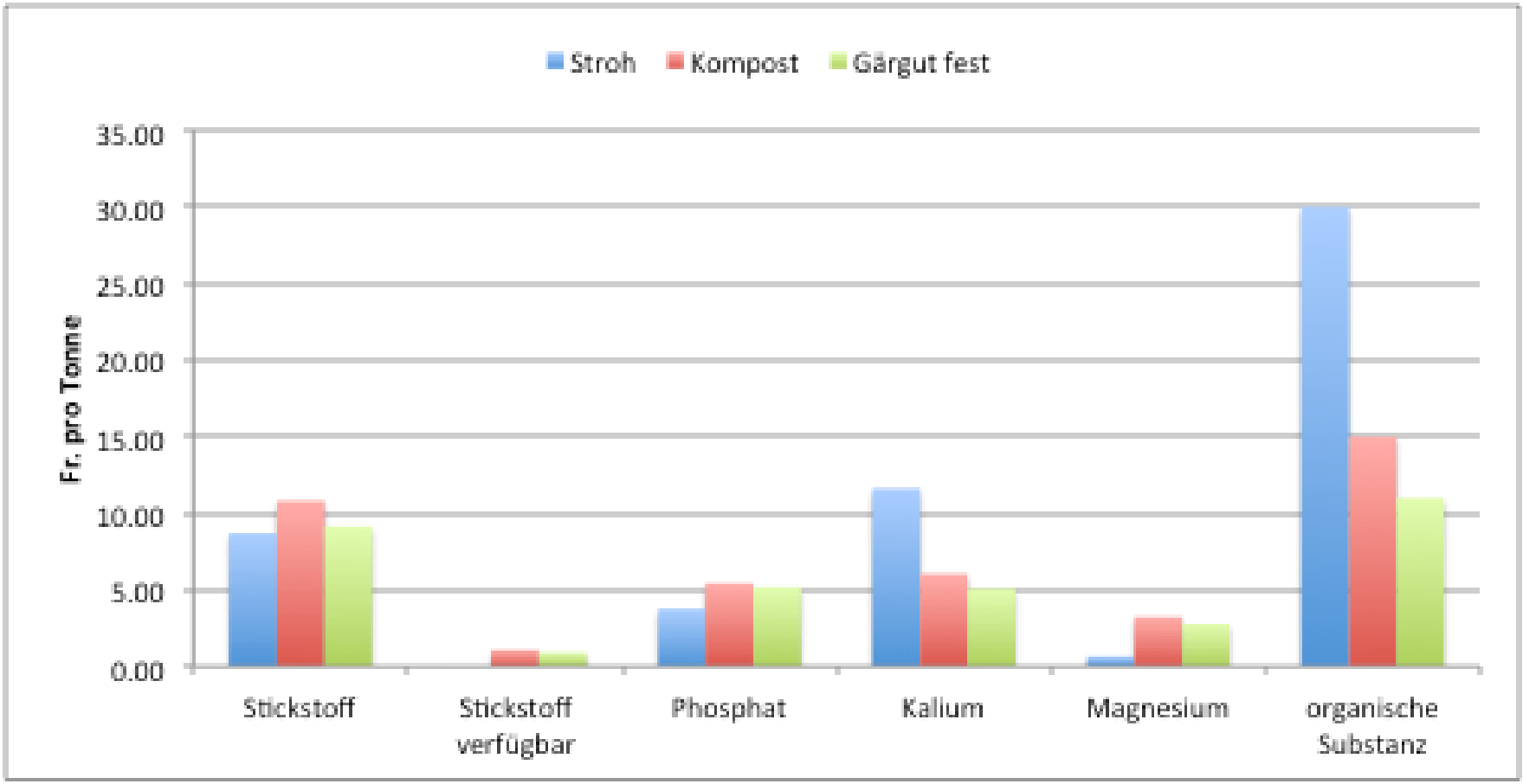
Economic value of compost

Organic matter in compost and digestate

Value of fertilising elements and organic matter, for straw, compost and solid digestate



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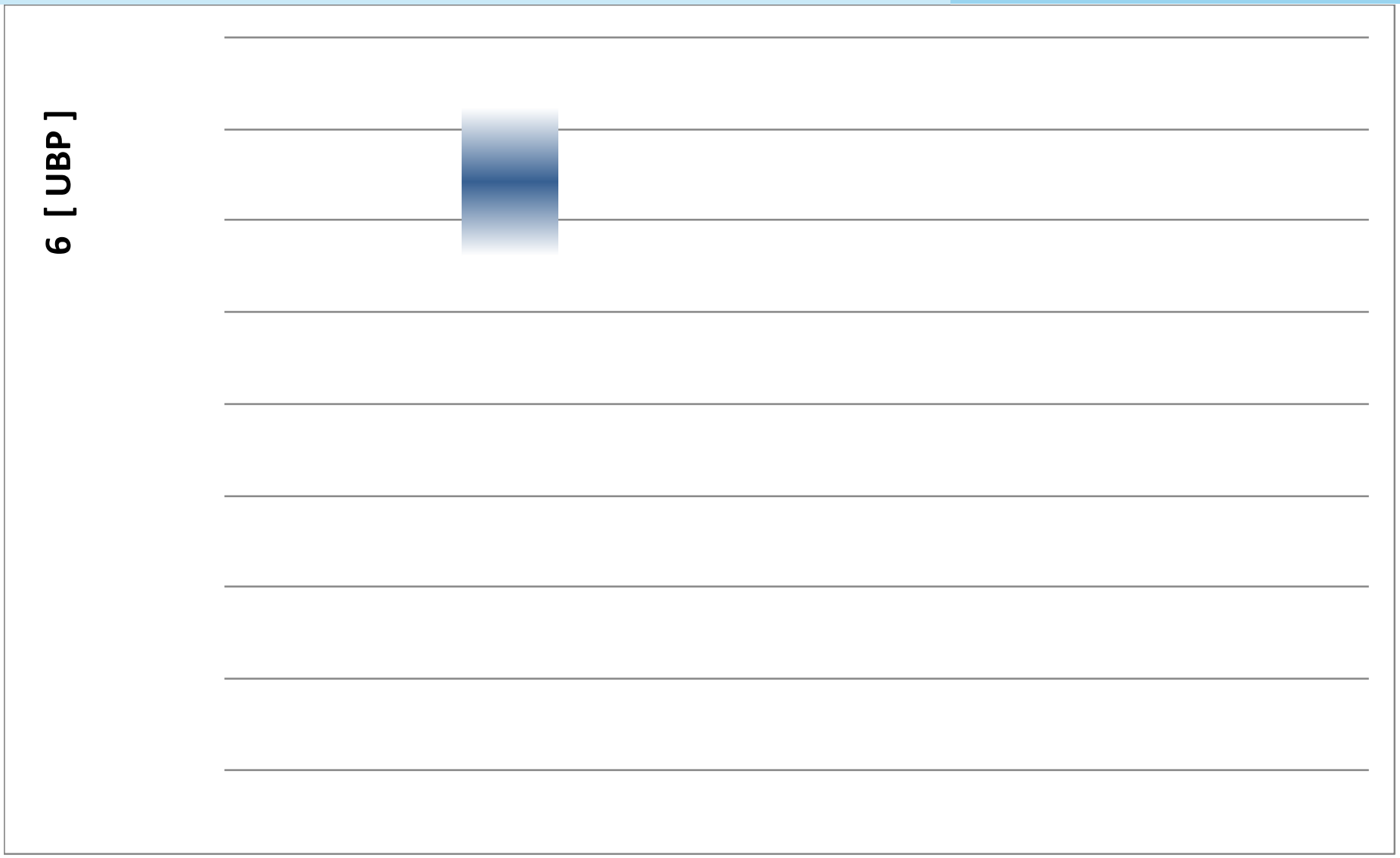
Ecologic values of the organic matter in compost

Organic matter in compost and digestate



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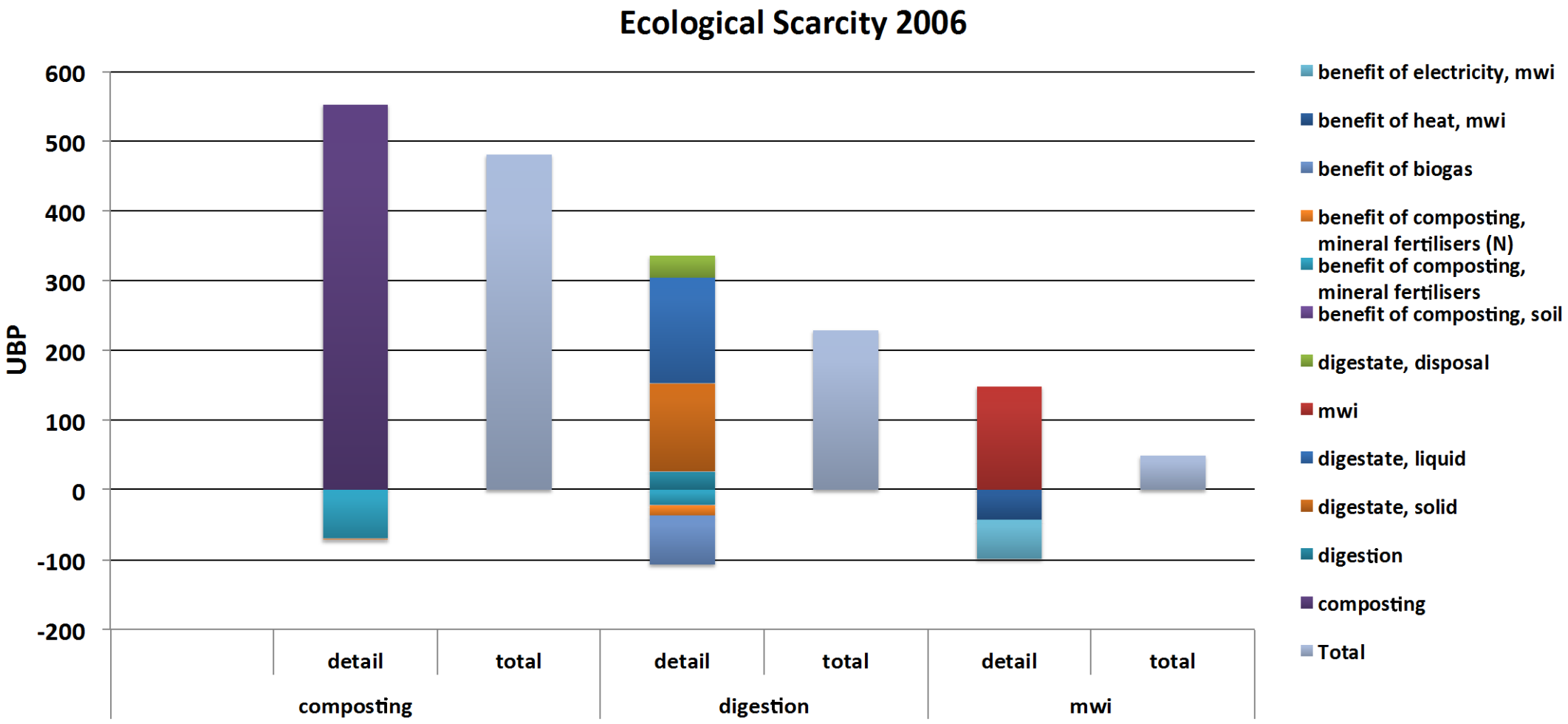
Heavy metal emissions into soil

- LCIA show significant influence of heavy metals on results:
  - Ecological scarcity method 1997 and 2006
  - Eco-Indicator 99
  - (ReCiPe)
- Different approaches / methods, none is "best" or "worst"

Environmental impact measured in UBP 2006

Heavy metal emissions into soil



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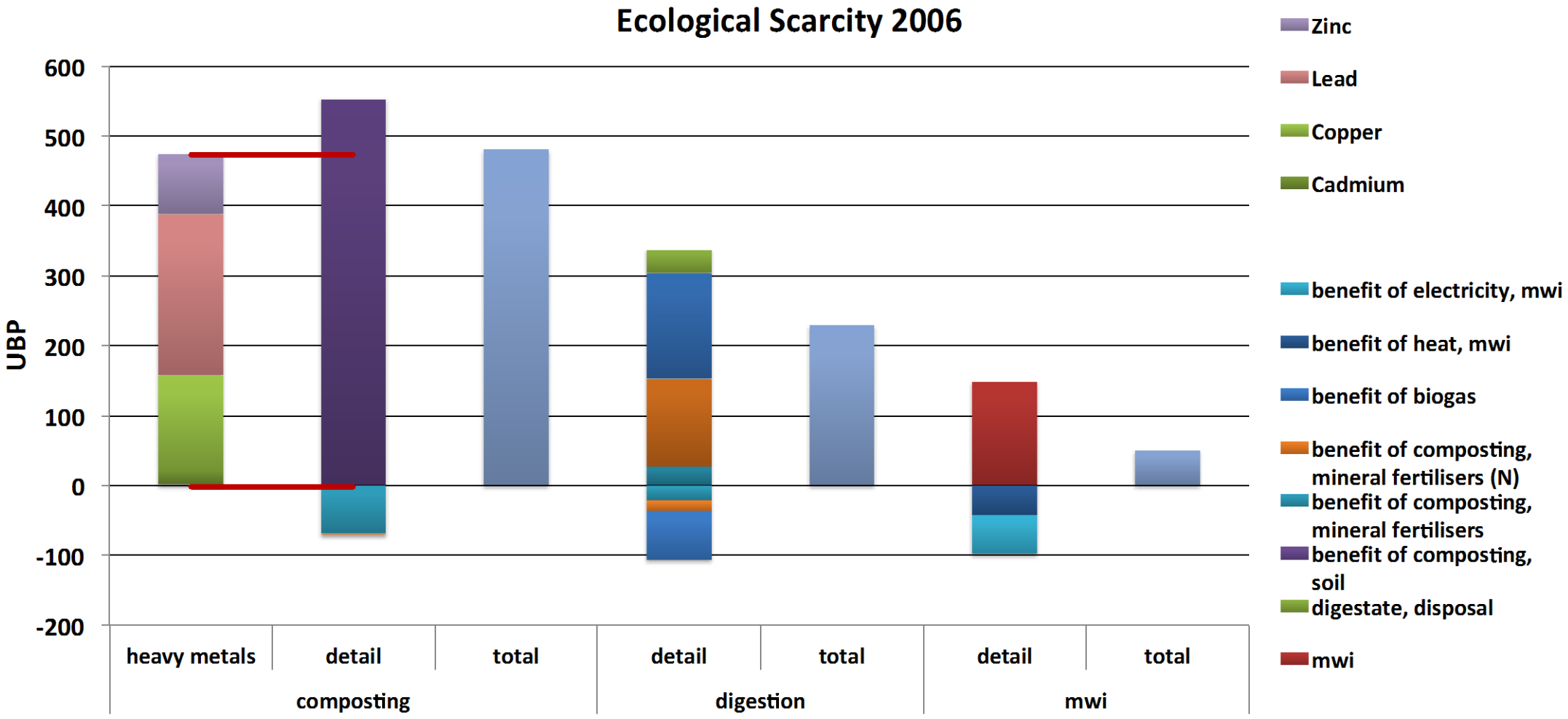
Share of heavy metal to the environmental impacts in UBP 06

Heavy metal emissions into soil



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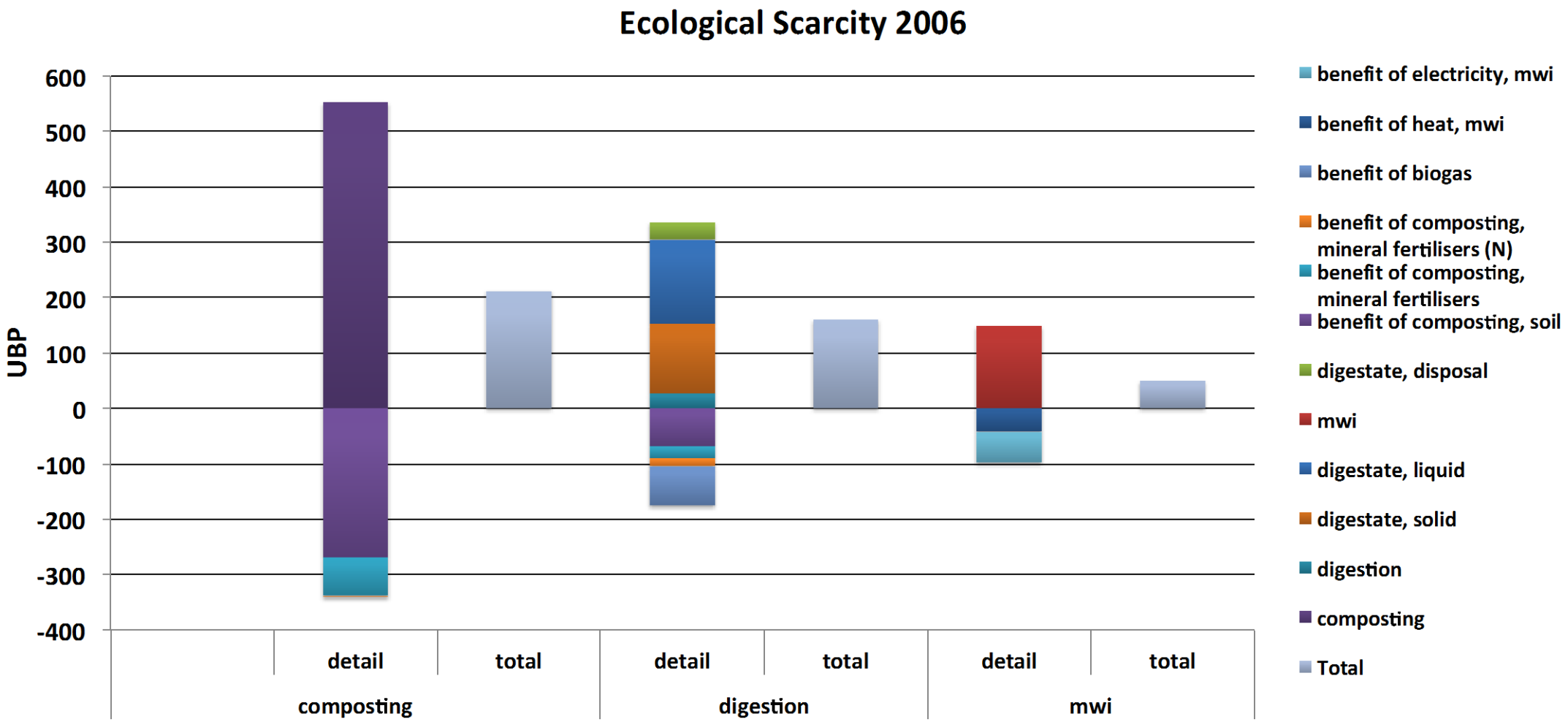
Taking into account organic matter [UBP 2006]

Heavy metal emissions into soil



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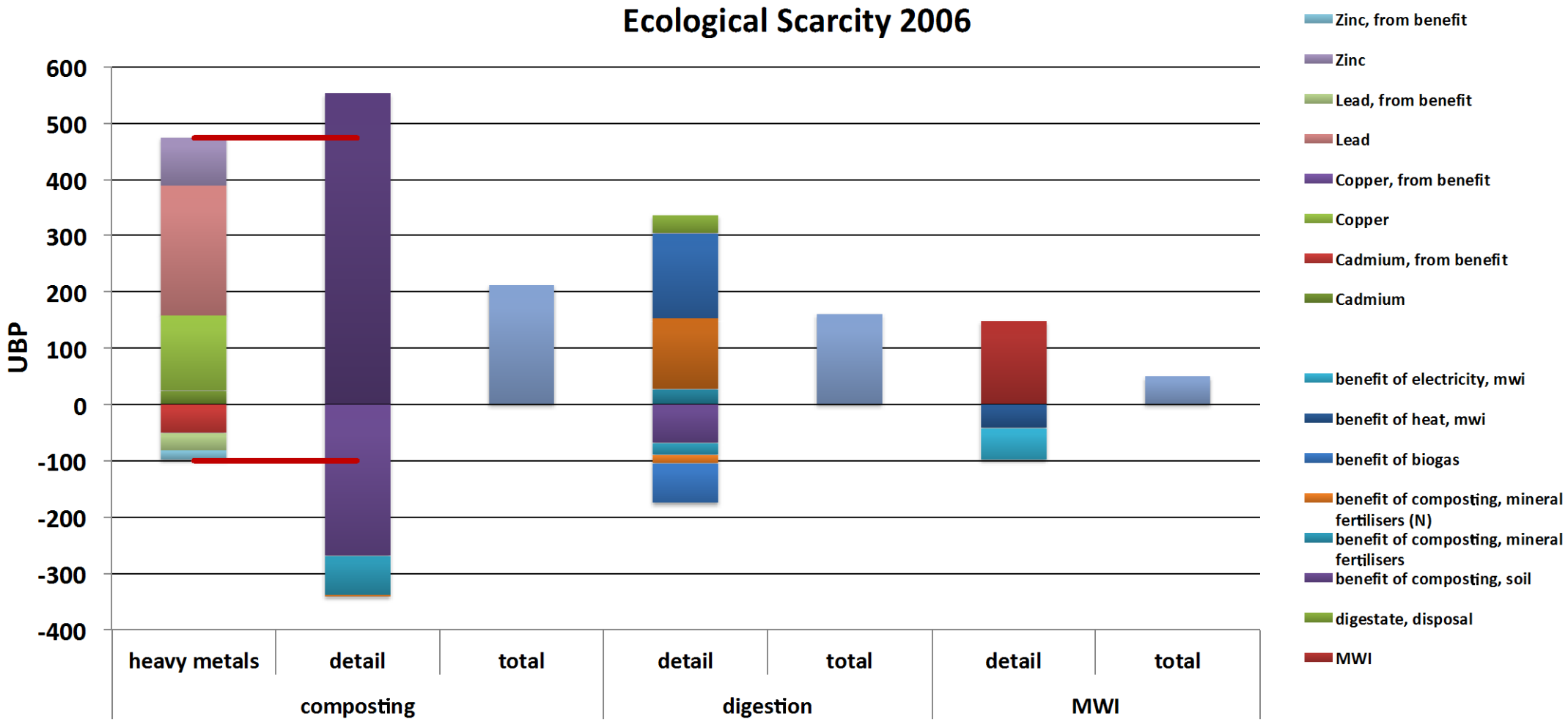
Taking into account organic matter [UBP 2006]

Heavy metal emissions into soil



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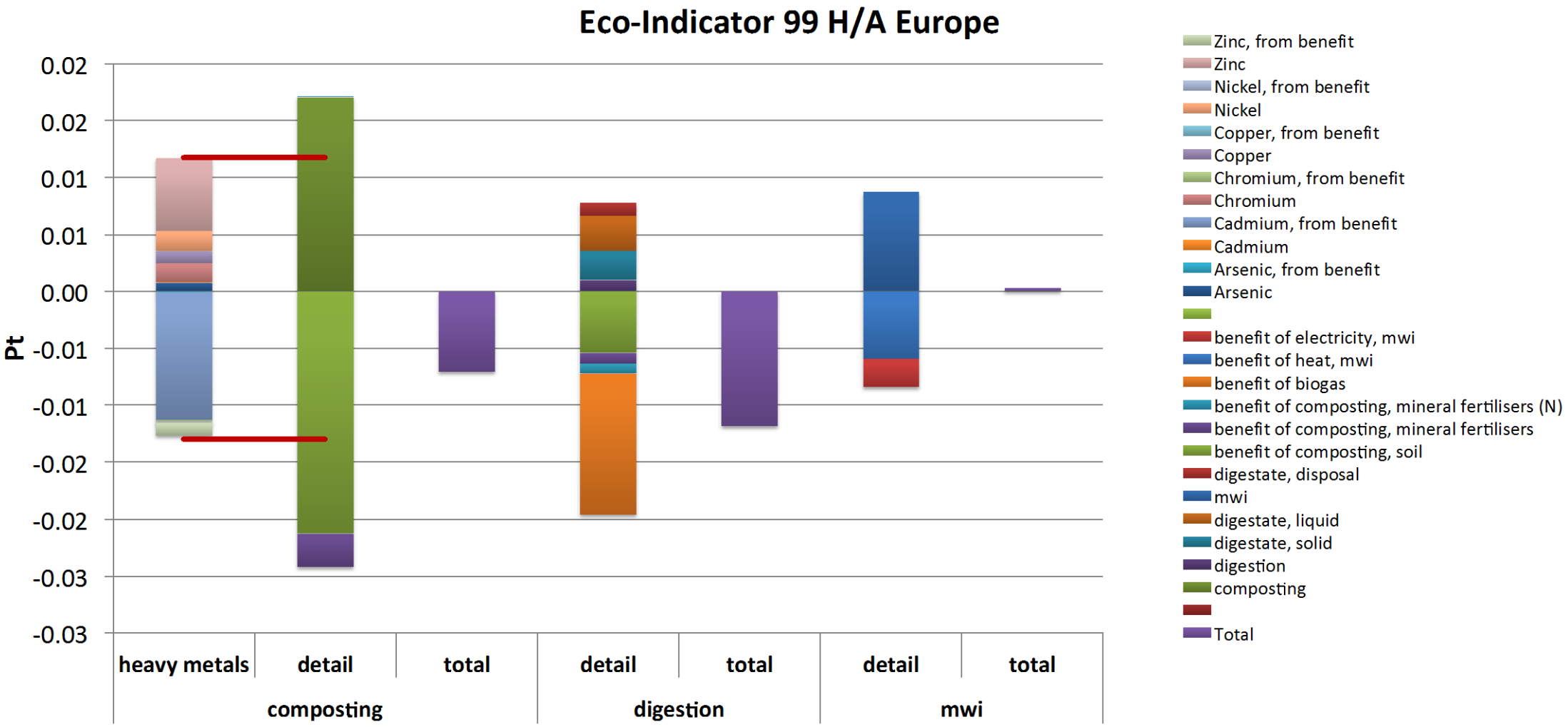
Taking into account organic matter [Eco Indicator 99 HA]

Heavy metal emissions into soil



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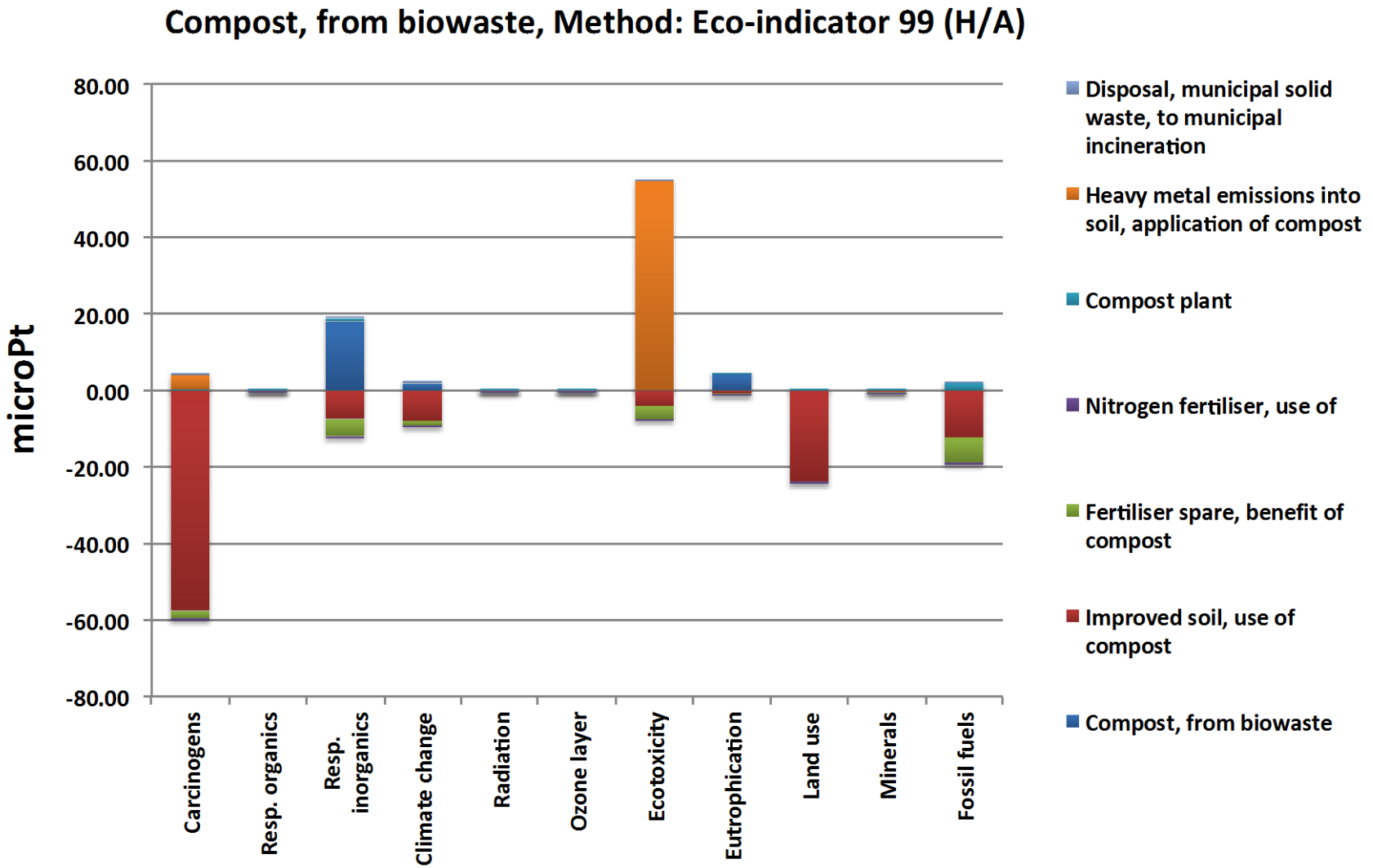
Share of the different impacts to the environmental impacts Eco-Indicator 99 (H/A)

Heavy metal emissions into soil



- Largest impact from toxicity midpoint categories
- Other methods show similar results
- Eco-Indicator 99 has another approach to toxicity of heavy metals than ReCiPe ➔ results not comparable

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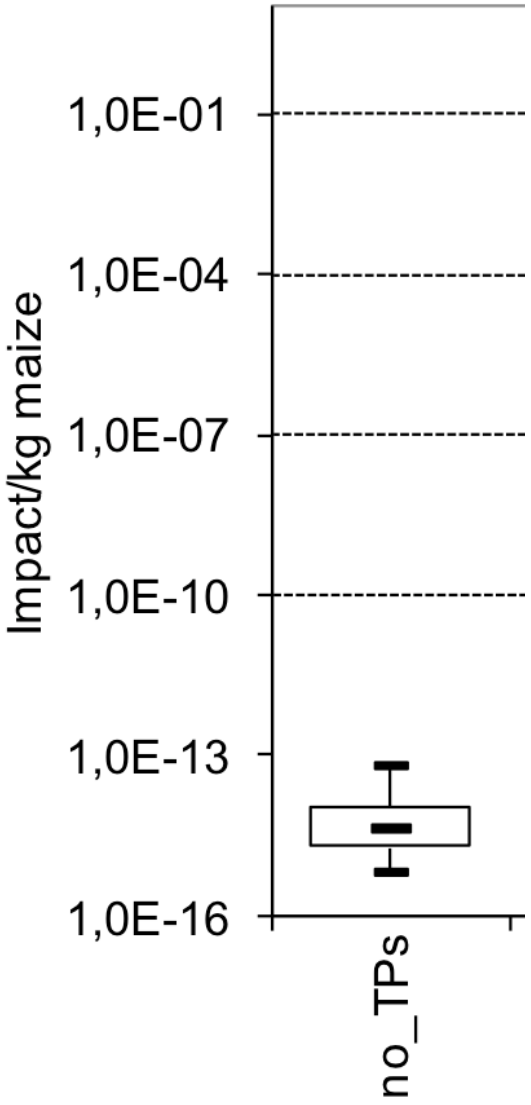
Uncertainty

Heavy metal emissions into soil



- Statistical uncertainty from measurement errors and limited sample size
- Measured data for toxic effects extrapolated to humans/animals with large safety margin
- Models describing toxicity interaction with large uncertainty

Figure from: Uncertainty in life cycle impact assessment: typologies, tools and a case of ecotoxicity; Mark Huijbregts and Rosalie van Zelm Radboud University Nijmegen; January 2012

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Heavy metal emissions

- Current inventories count each metal as though it was newly introduced into the system, but
  - Input material for compost usually contains some topsoil
  - Plant material going to composting and digestion contains heavy metals which are already in the cycle

➢ Most inventories count too many heavy metals

- Solubility/bioavailability of metals not considered in the methods examined (contrary to Swiss law)

Heavy metals

Conclusions

- Heavy metal inputs into soil come from different sources, not all are differentiated in LCIA methods
- High uncertainty in toxicity data / methods and large variations in local concentrations and sources: risk assessments for heavy metals into soil difficult
- Soil is a complex matrix
- Environment is complex

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Results

- Emissions of biological treatment methods are too high in ecoinvent
- Effects of accounting organic matter in compost and digestate are significant
- Heavy metal emissions into soil have great impact on LCIA results and should be investigated in more detail

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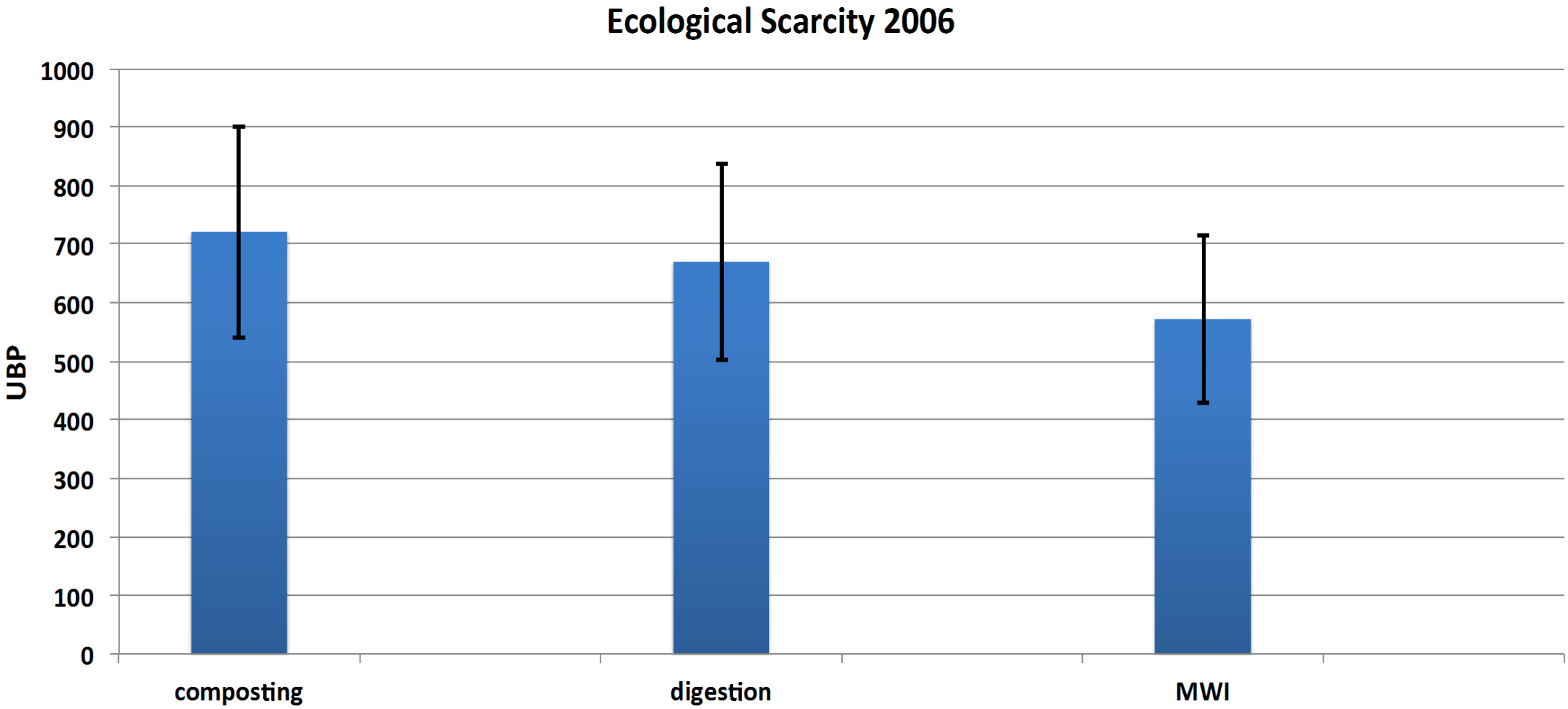
Results



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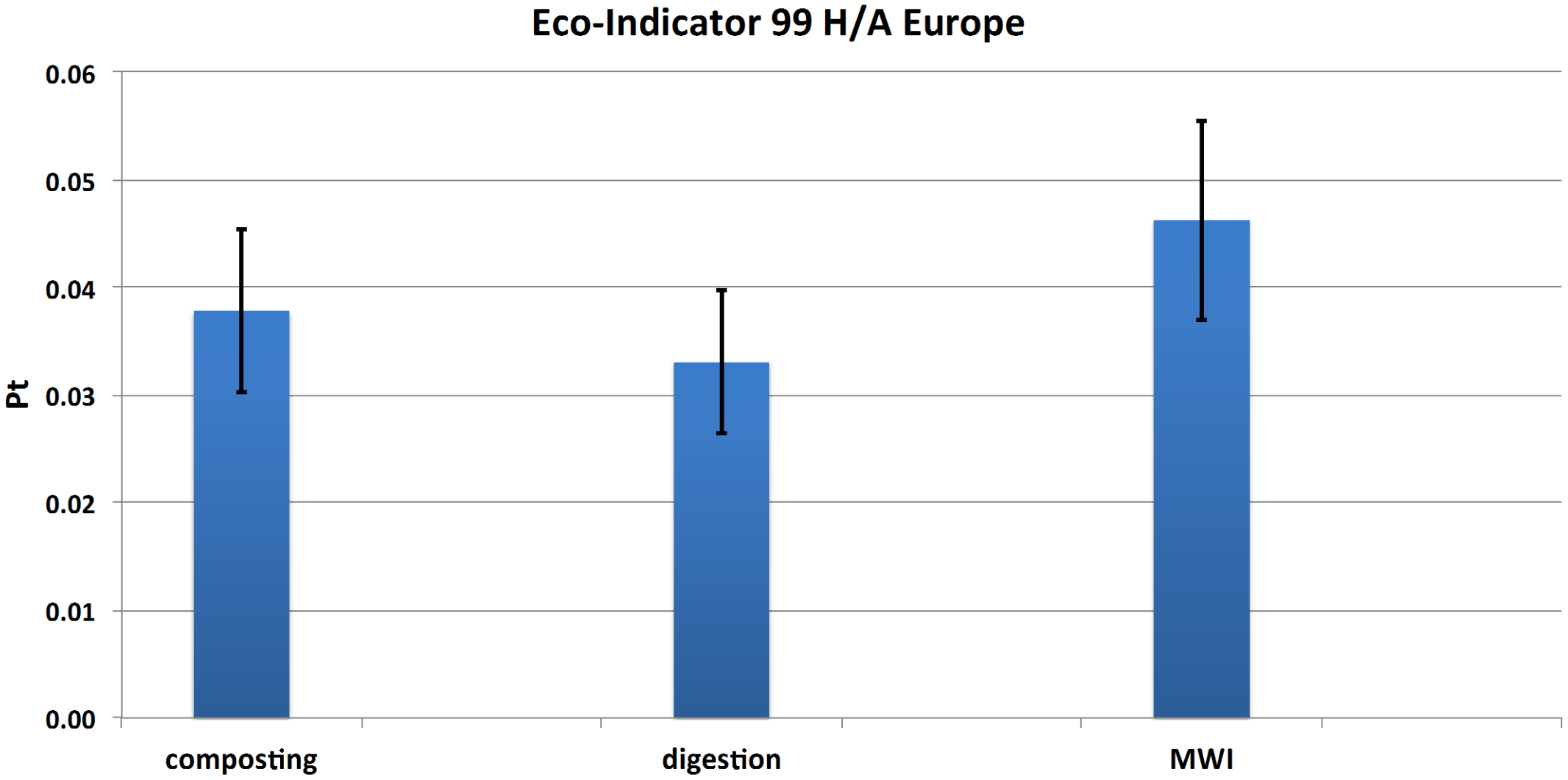
Results



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Conclusions

- Considering all the new findings, all the methods examined lead to similar results, if planning and management of the disposal is adapted to the material:
  - Polluted ➔ MSWI
  - Wet, easy degradable /high fat content ➔ anaerobic digestion
  - Dry and woody ➔ incineration
  - Mixed soil with lignified plant material ➔ composting

- System model for other types of biowaste created based on new data

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