KOMPETENZZENTRUM Wasser Berlin

LCA and risk assessment of sewage sludge application to land compared to phosphorus recycling technologies

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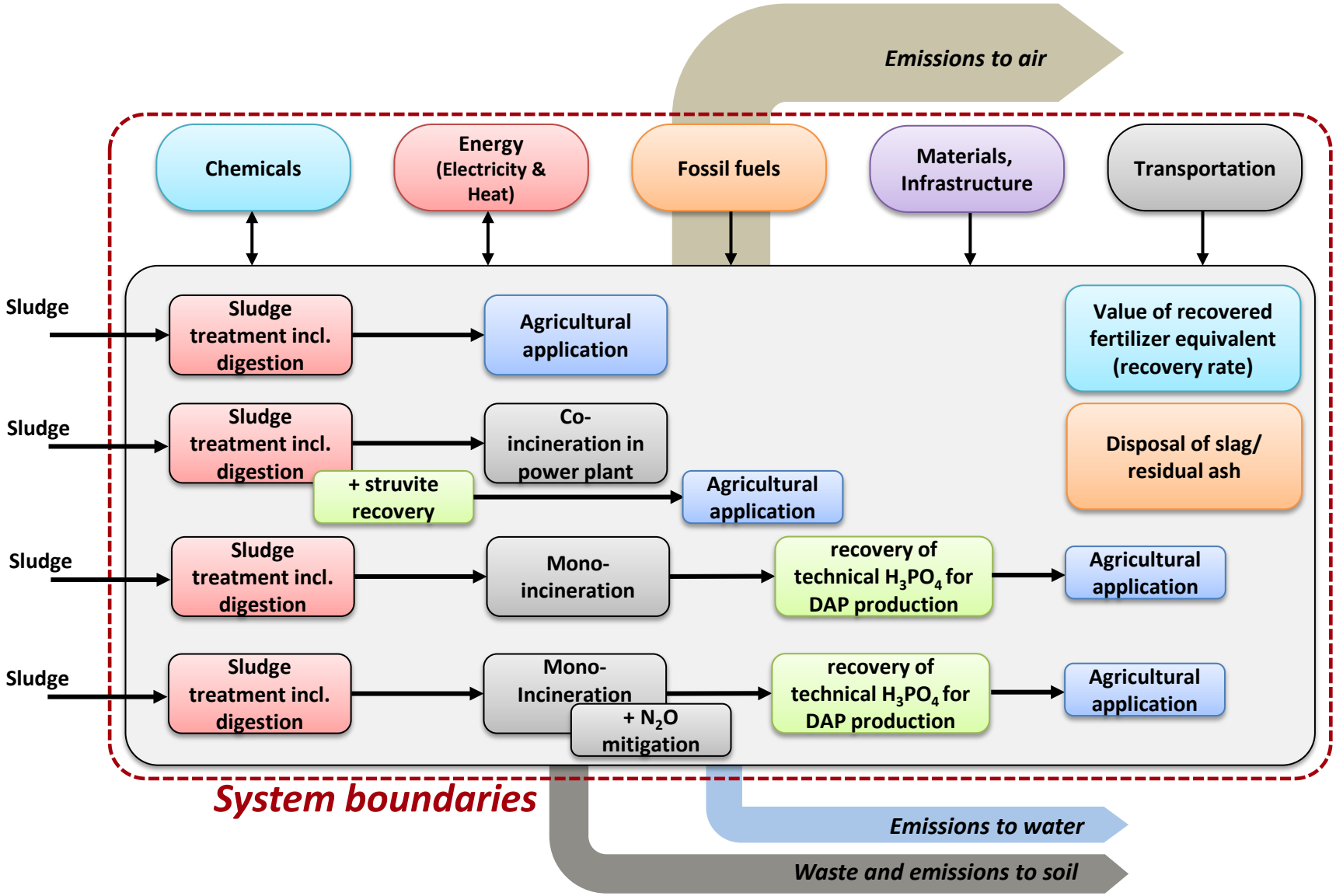
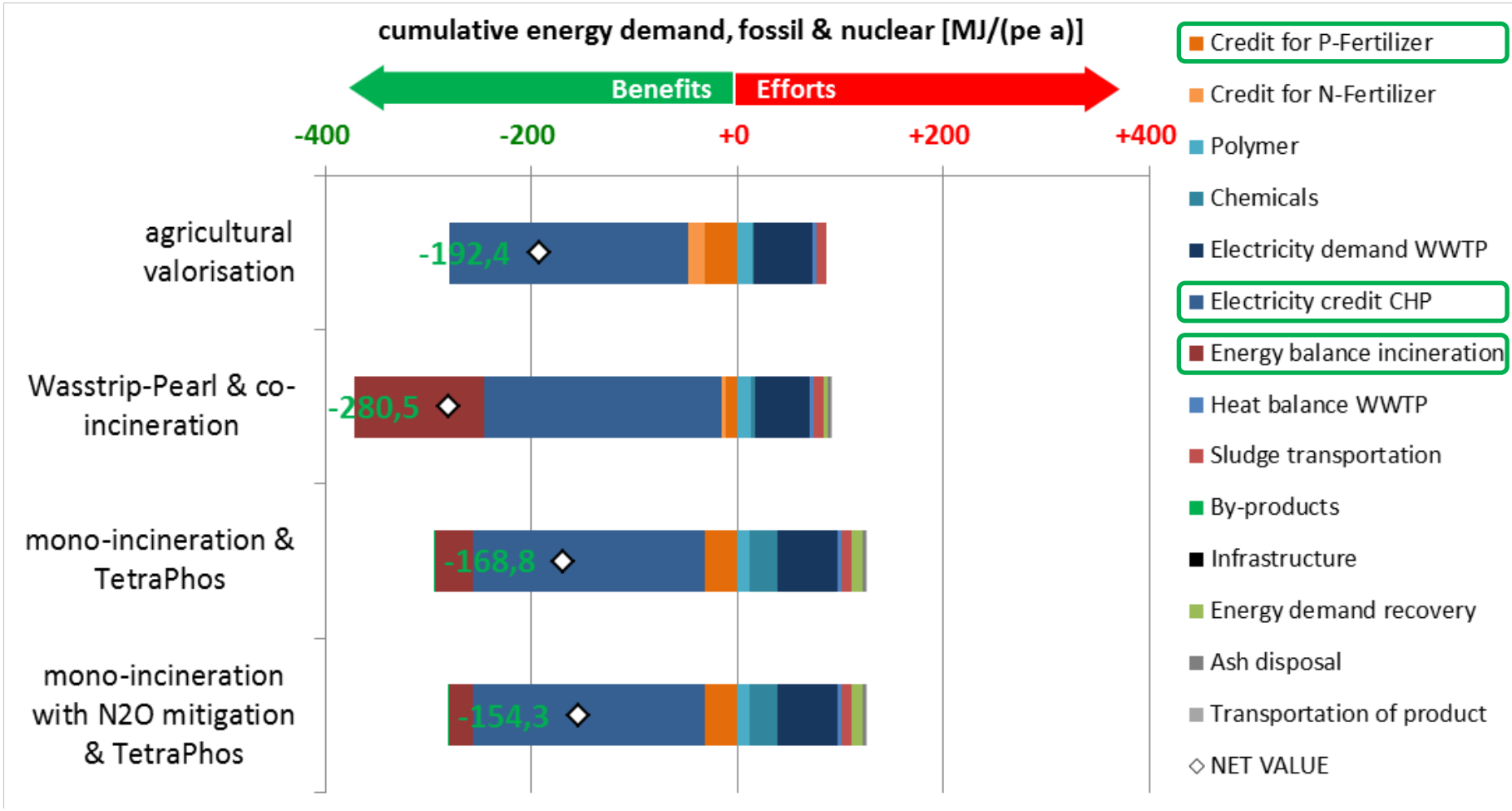
Scope, System boundaries (simplified)



Non-renewable cumulative energy demand (CED)

coal, oil, natural gas, uranium



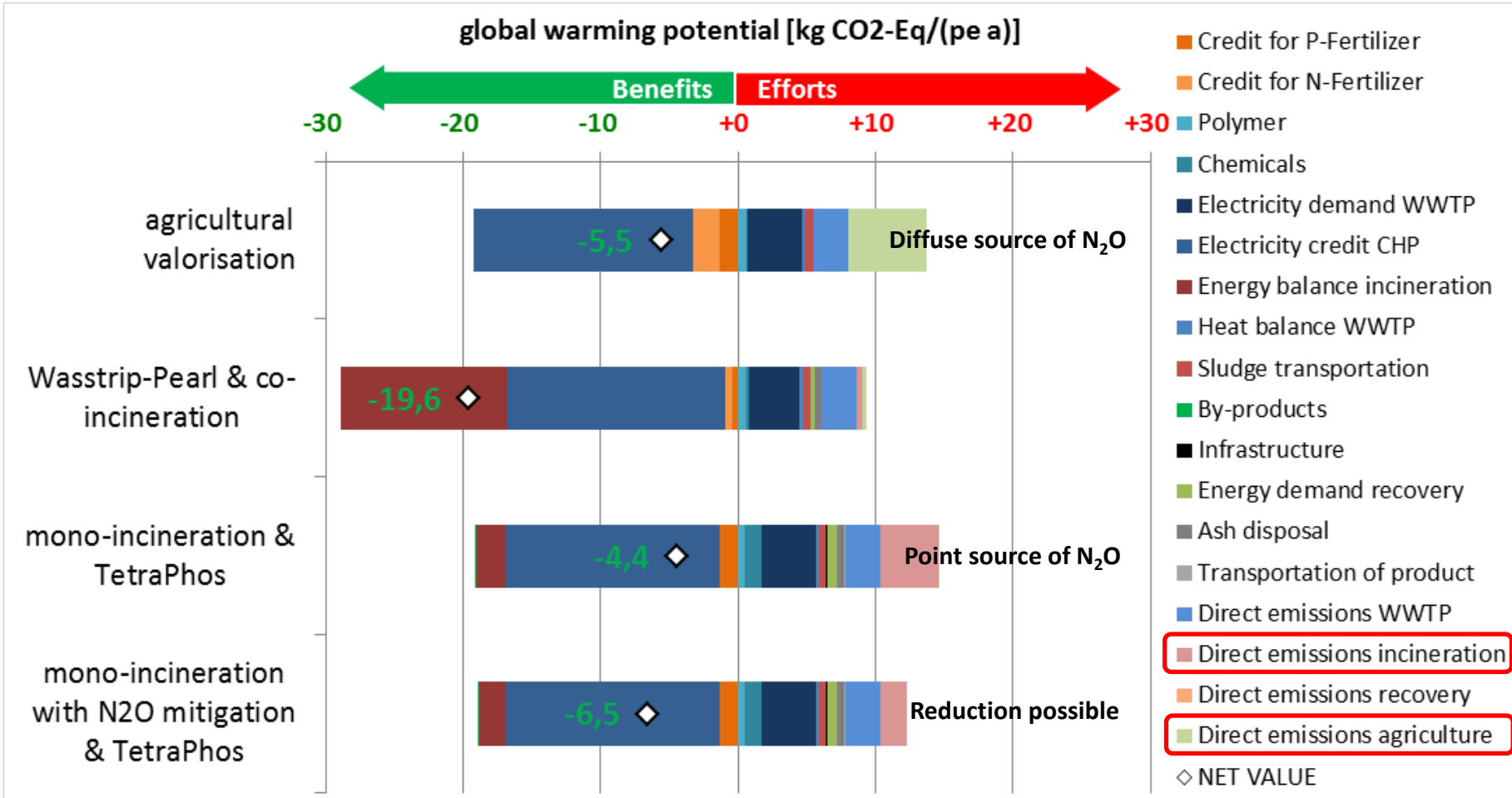
Take home messages:

#1 anaerobic digestion highly advantageous

#2 turn-off between energy recovery via power plant and P recovery

Global warming potential (GWP

Fossil CO_2, CH_4, N_2O

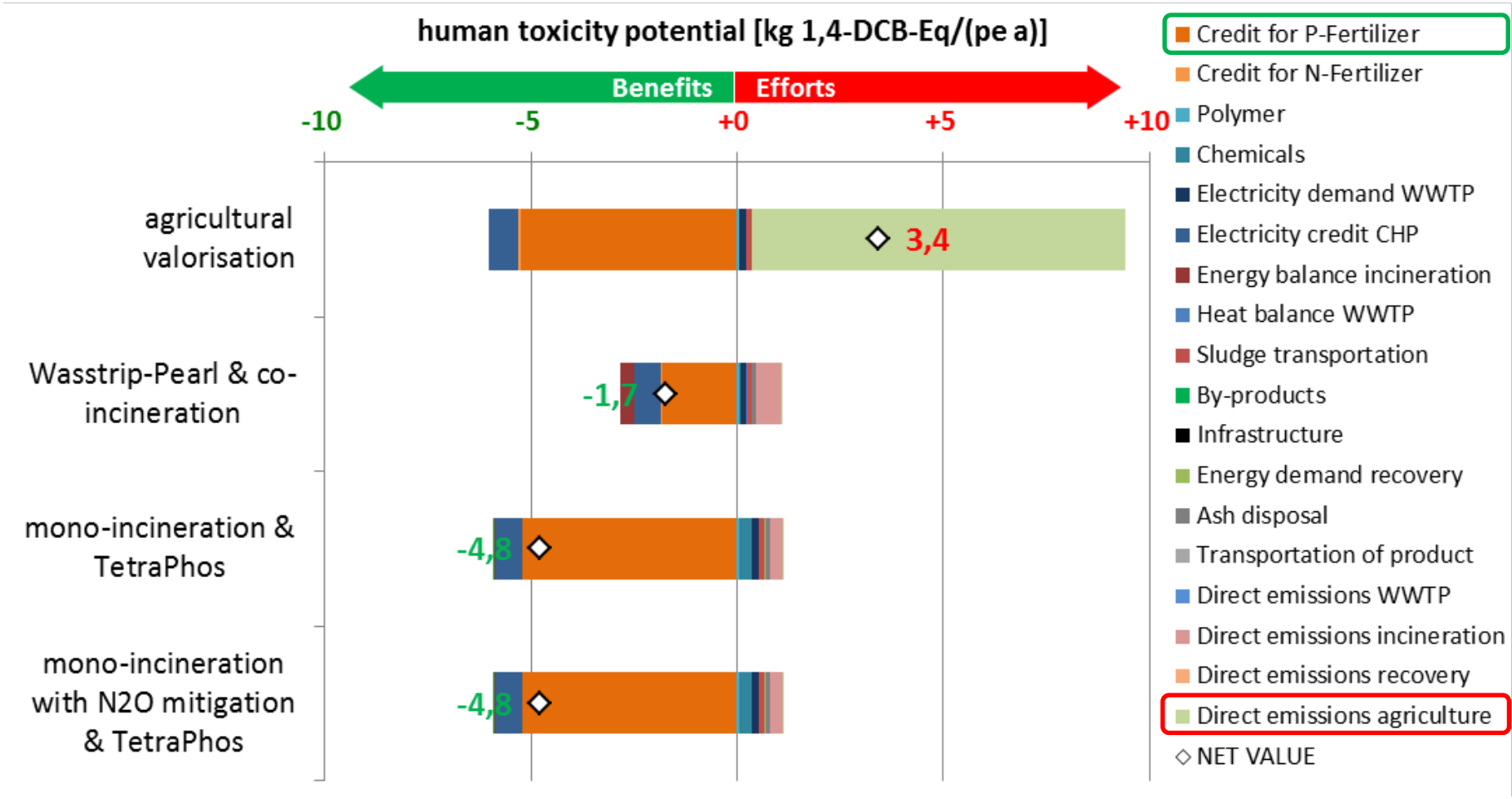


Take home messages:

#1 indirect emissions (energy recovery) determining overall footprint

#2 direct emissions (N_2O) relevant! – reduction of point sources reasonable

Human toxicity potential (HTP)
heavy metals in agricultural soils



Take home messages:

#1 Struvite and technical P-acid are products with negligible contaminant-level

#2 (Sludge and) sludge ash contains high HM-loads, HM removal recommended

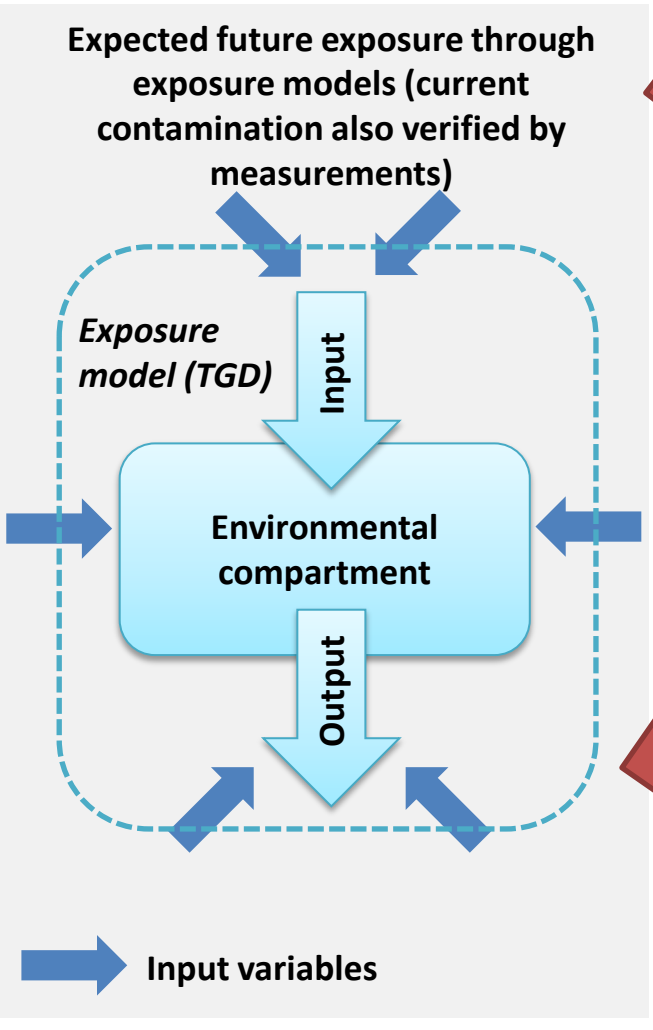
Summary

- Sludge valorization in agriculture is from the overall energy perspective advanced compared to mono-incineration (and P recovery from ash) due to partly substituted nitrogen and lower energetic efforts. However high metal loads and other potential hazardous substances are also put to arable land.

- A combination of struvite recovery in EBPR in combination with energetic valorization of sludge in a power plant reveals environmental benefits in terms of Energy recovery and GWP, it is accompanied by operational benefits (e.g. reduced sludge volume due to improved dewatering) and high electric efficiency in the power plant

- P recovery from ash after mono-incineration can reduce the GWP compared to agricultural sludge valorization if N_2O mitigation measures are put in place and it can reduce the input of hazardous substances if a recovery process is chosen, that significantly reduces metal contamination compared to sludge ash

Environmental risk definition



Knowledge about environmental fate of contaminats

$$RQ = \frac{PEC}{PNEC}$$

Knowledge about toxicity of contaminants

Toxicity tests

- Ecotoxicity
- Human toxicity

Assessment factor

- Expression of knowledge
- Depending on the type of tests and the number of trophy levels tested

PNEC per endpoint

- Soil organisms:
  - Ecotoxicity tests for soil organisms
  - Derived from toxicity test for water organisms
- Groundwater (and pore water):
  - Ecotoxicity tests for water organisms
  - Minor threshold values for groundwater
  - Tolerable daily intake (humans)
- Humans
  - Tolerable daily intake

RQ:	Risk quotient
PEC:	Predicted environmental concentration
PNEC:	Predicted no-effect concentration
TGD:	Technical Guidance Document on Risk Assessment

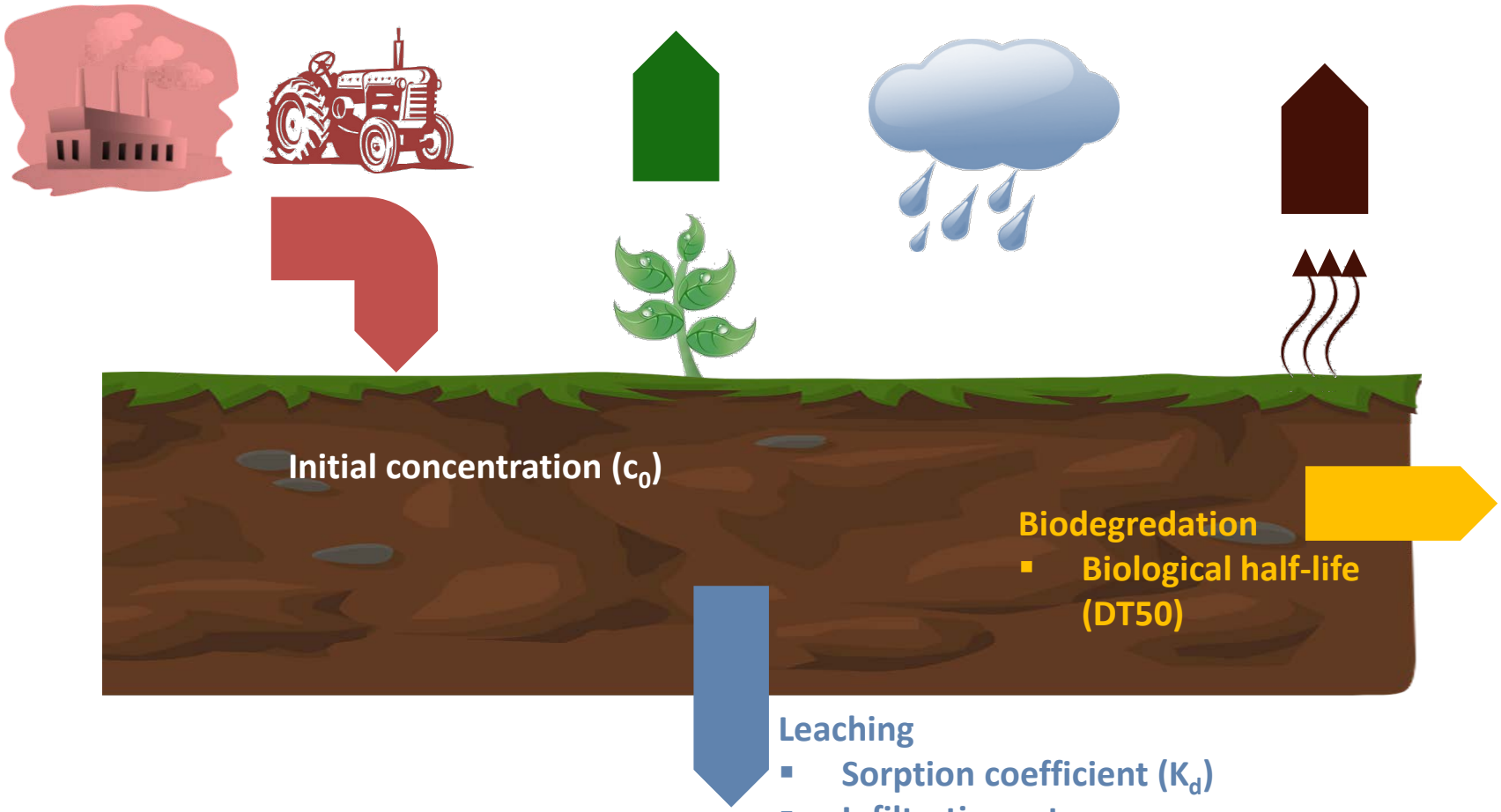
Exposure model

Atmospheric deposition and fertilizer application
- Fertilizer amount
- Pollutant concentration

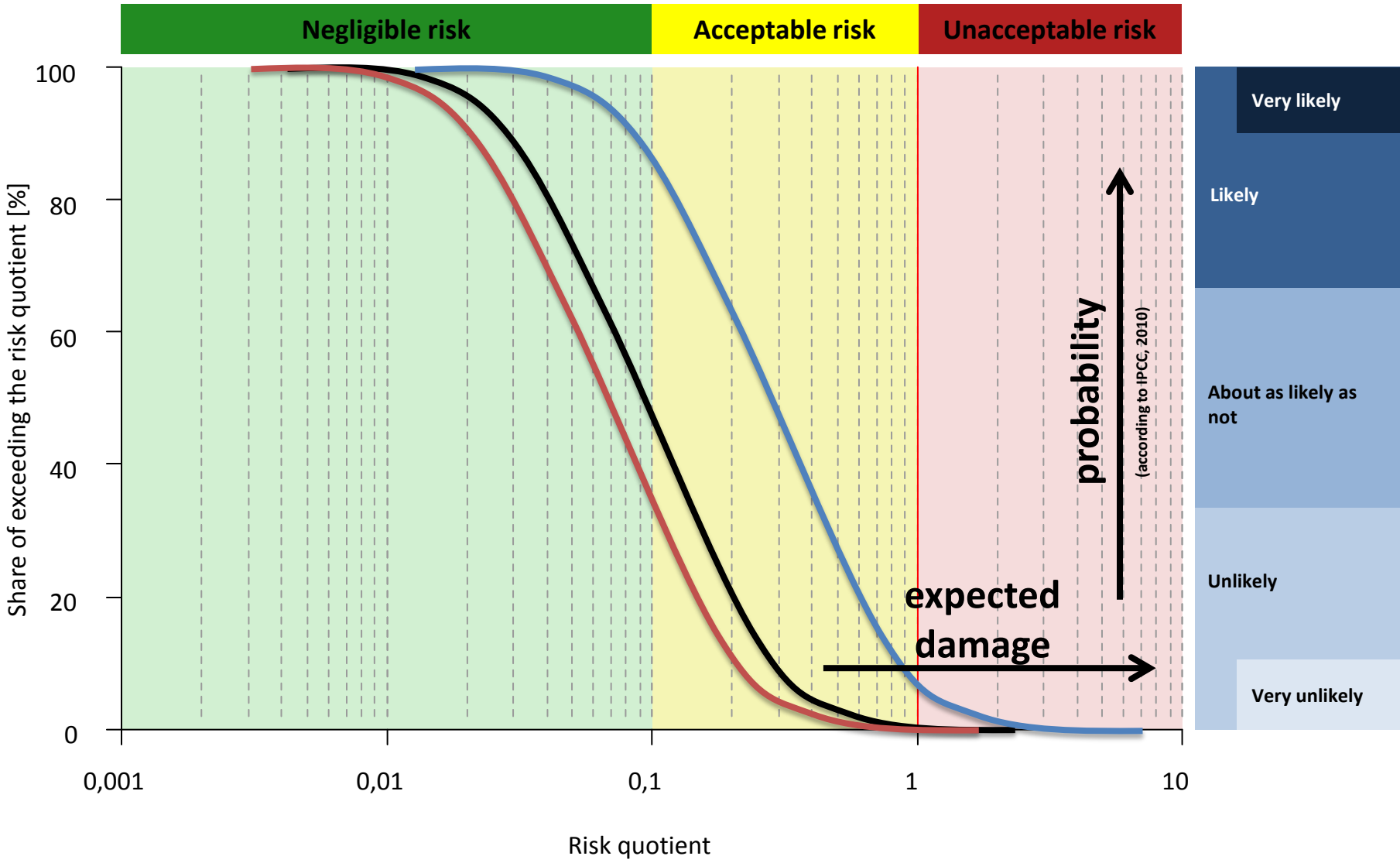
Plant uptake
- Bio-concentration-factor (BCF)

Precipitation

Volatisation
- Henry-constant (K_H)



Results of probabilistic risk assessment



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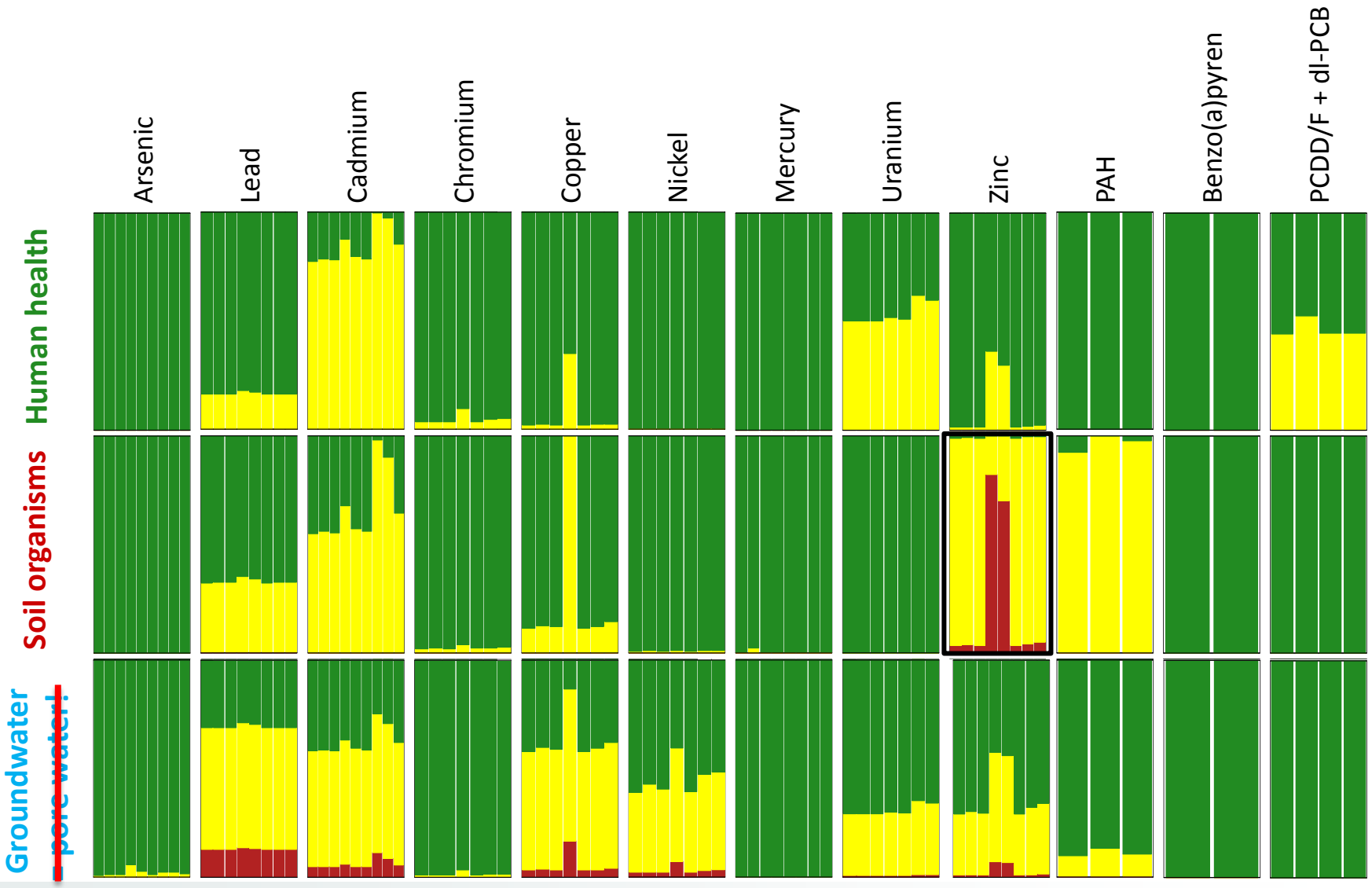
Results of probabilistic risk assessment



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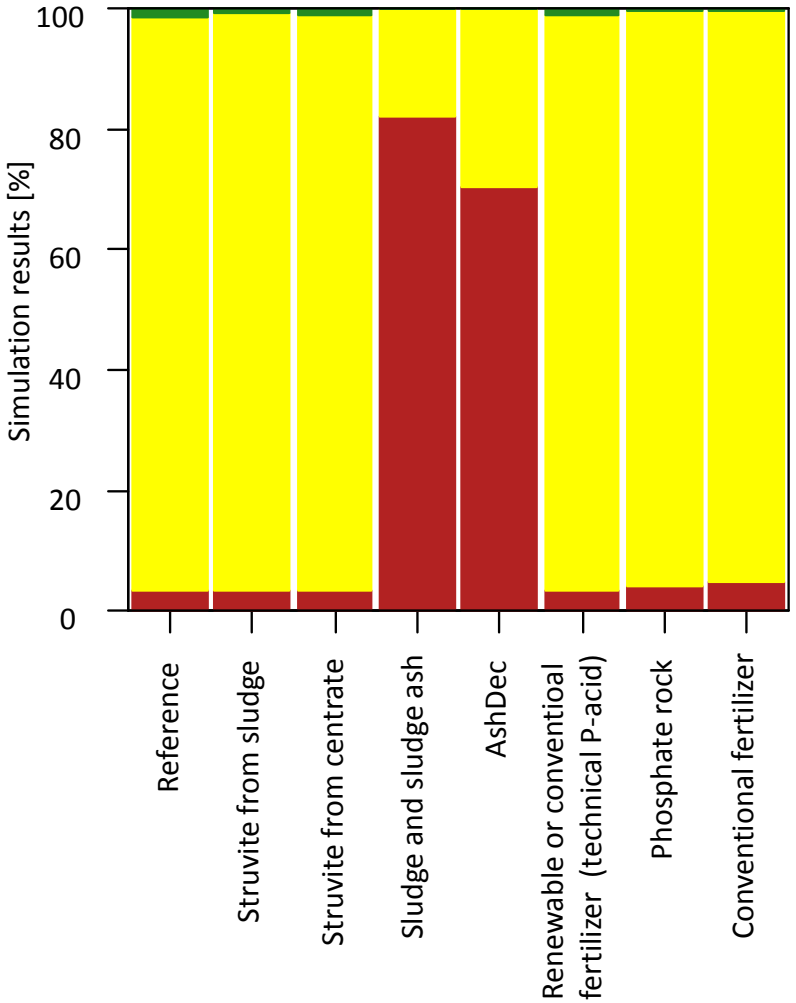
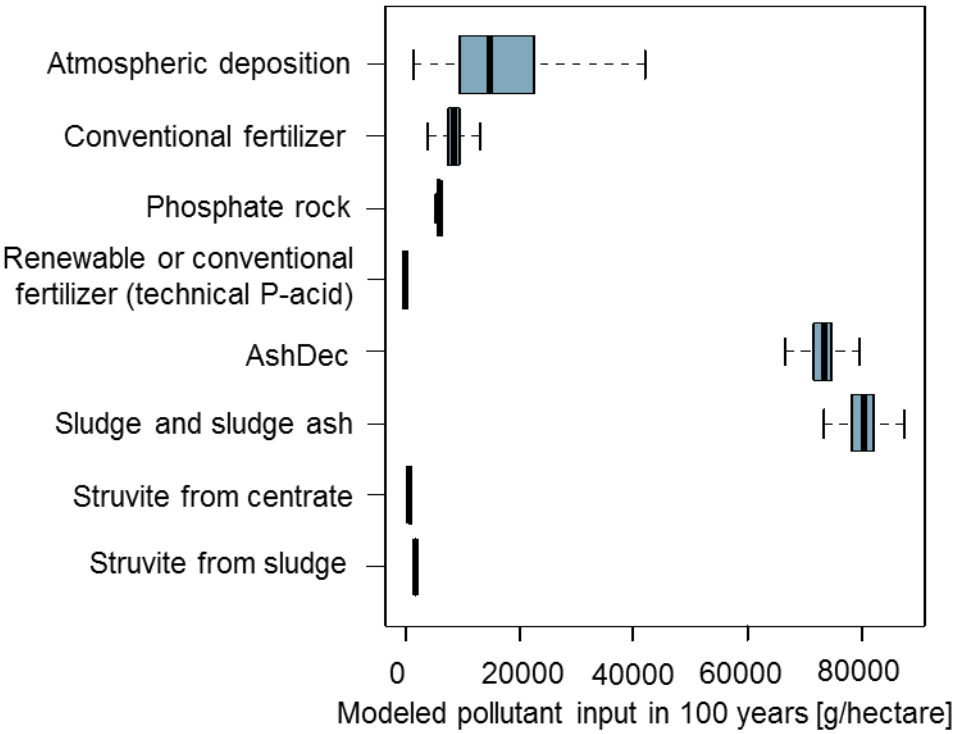
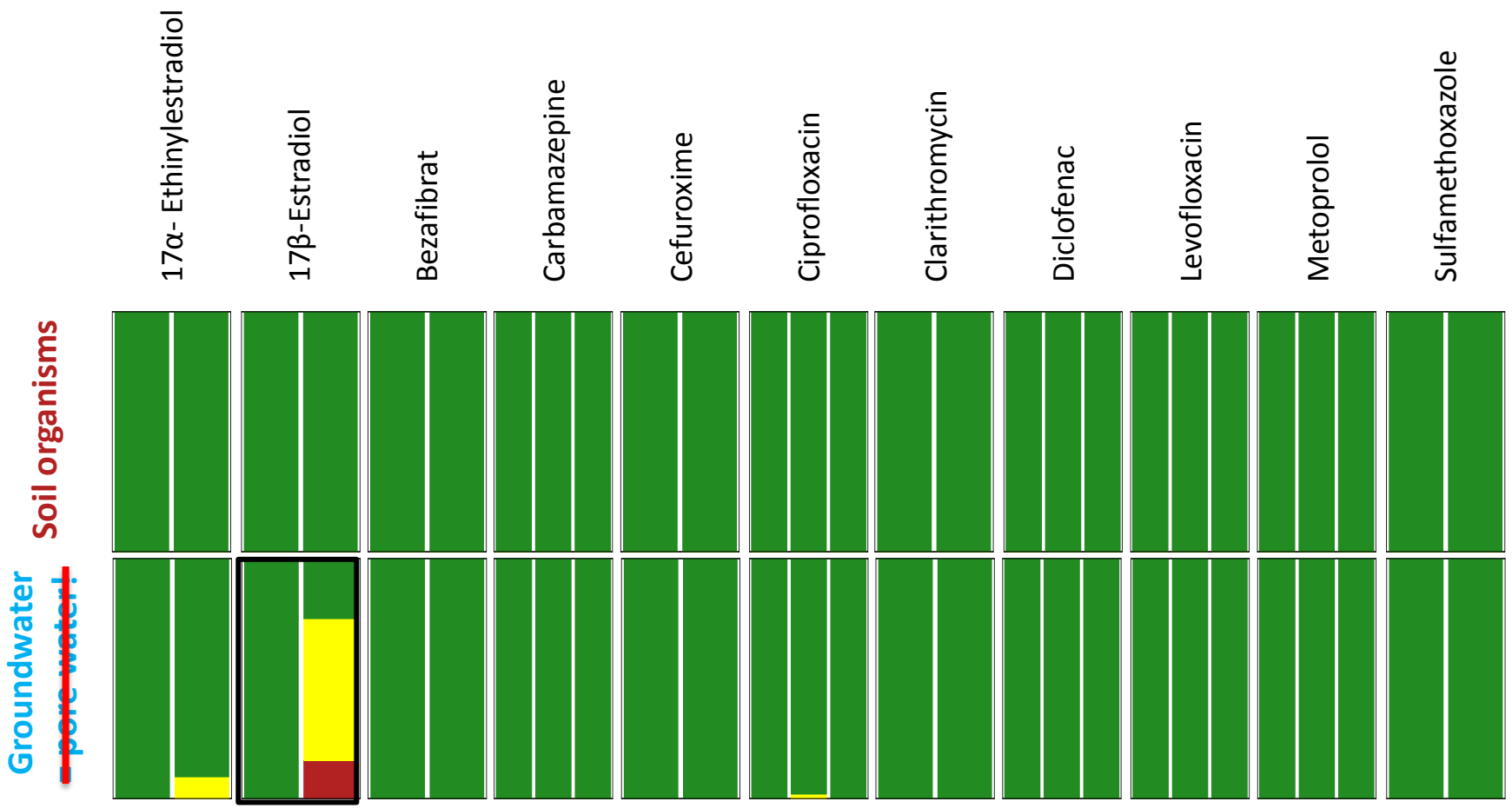
Zinc and endpoint soil organisms



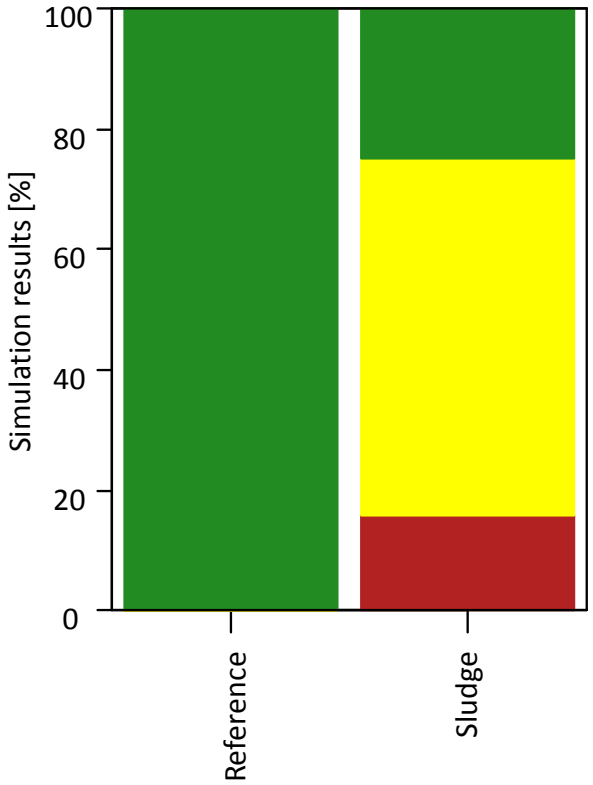


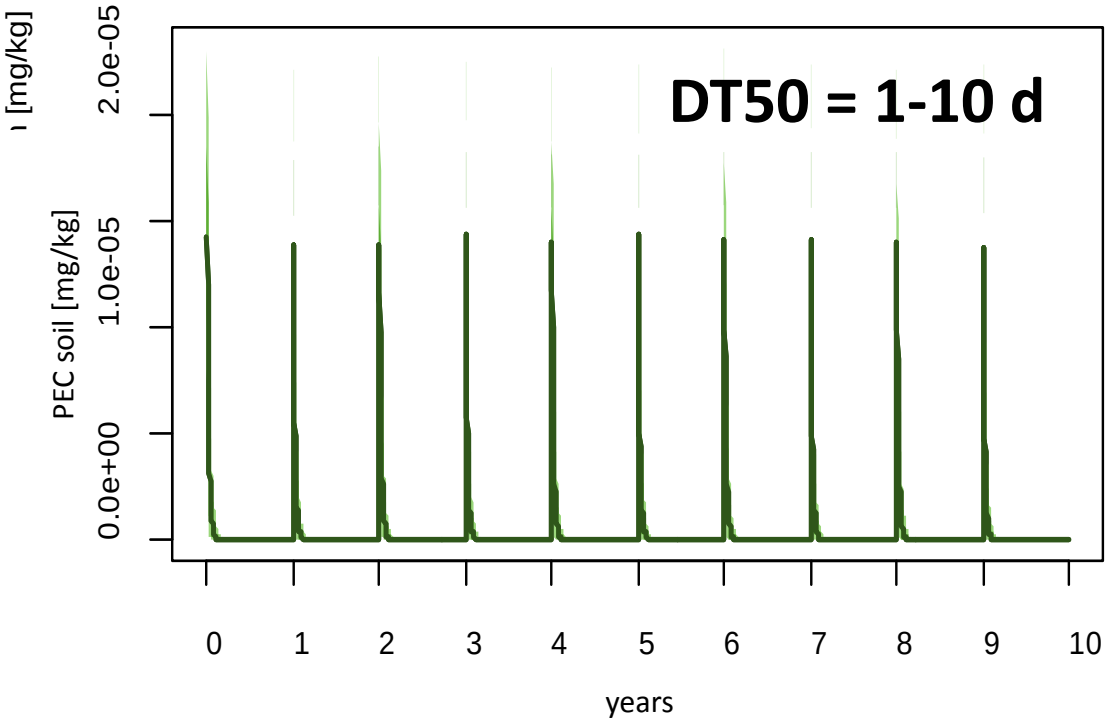
	mg Zn/kg P_2O_5	n
Conventional fertilizer	1 409 ± 2 893	104
Phosphate rock	807 ± 560	31
Renew. or conv. fertilizer (technical P-acid)	4,5 ± 1,5	3
AshDec	12 195 ± 3 545	150 (calc)
Sludge and sludge ash	13 402 ± 3 882	150
Struvite from centrate	124 ± 160	10
Struvite from sludge	264 ± 145	8

Results of probabilistic risk assessment



17β-Estradiol and endpoint groundwater





Summary

Under the background of made assumptions…

- An exceeding of the TDI (endpoint **human health**) is not expected (cadmium is priority hazard)
- An exceeding of the PNEC for **soil organisms** could not be excluded for zinc, whereby sludge and sludge ash significantly increase the risk quotient
- **Groundwater** is the most sensitive endpoint:
  - an exceeding of the PNEC could not be excluded for several heavy metals
  - this accounts especially for cadmium (sedimentary phosphate rock and conventional fertilizers produced from sedimentary rock) and copper and zinc (sludge and sludge ash)
- Struvite and fertilizers derived from technical phosphoric acid do not increase risks for any included substance in the assessment
- An actual exceeding of any PNEC is **unlikely** for organic substances (incl. pharmaceutical residues) also for sludge

Recommendation

What should Europe do?

- Traditional sludge valorization in agriculture?
- Struvite recovery prior sludge disposal?
- Recovery from ash after mono-incineration?

It depends on the local boundary conditions!

- **Agglomeration areas (> 1-3 Mio pe):** reasonable economy of scale for mono-incinerators and P recovery plants from ash

- **Rural areas:** either long sludge transportation routes to have a reasonable economy of scale or other solutions than mono-incineration, e.g. struvite recovery and/or traditional sludge valorization (incl. quality control)