Time horizon dependency in toxicity potentials of metals

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Objectives

- Inclusion of time horizon dependency in fate factors of metals
- Comparison of 100 year and infinite time horizon fate factors of metals
- Validity and relevancy of time horizon dependency of metals

Toxic impacts in LCA

- Characterisation Factor $Q = F \cdot E$
- Fate factor $F = \frac{\partial \text{Concentration}}{\partial \text{Emission}}$
- Effect factor $E = \frac{\partial \text{Response}}{\partial \text{Concentration}}$

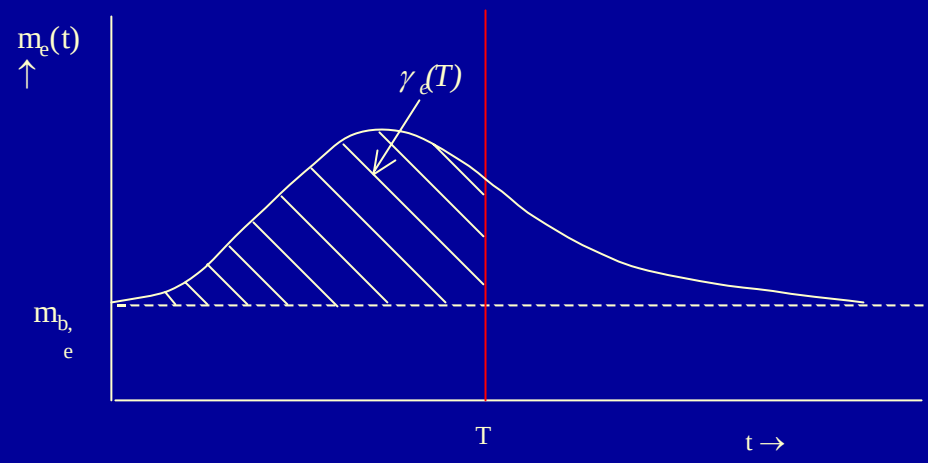
USES-LCA 2.0

- Ecological fate and effect factors for freshwater, sea water, oceanic and soil environment
- Human fate and effect factors for inhalation and ingestion
- Emissions to 10 compartments

USES-LCA 2.0

- Database of +/- 1000 pollutants (22 metal species)
- Simplebox 3.0 underlying fate model
- Steady state and dynamic calculations

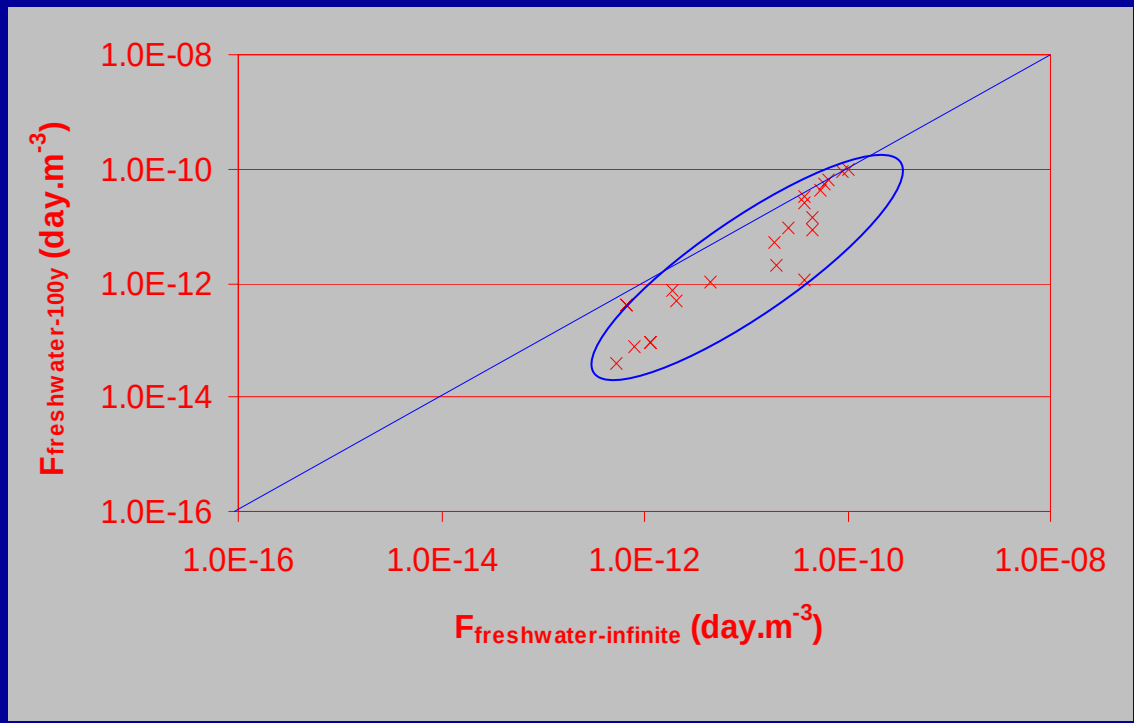
Dynamic calculations



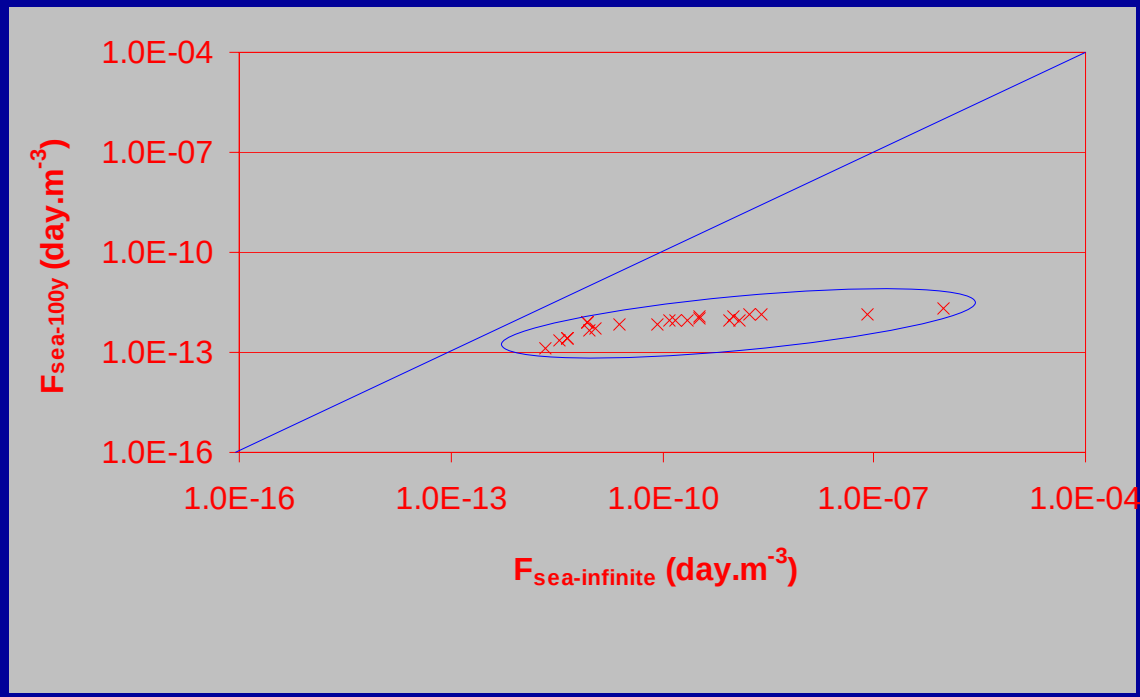
Time-integrated exposure over time period *T* is of interest:

$$\boldsymbol{\gamma}_{\mathbf{T}} = (\mathrm{e}^{\mathbf{TA}} - \mathbf{I}) \cdot \mathbf{A}^{-1} \cdot \boldsymbol{\Delta}\mathbf{m}$$

Freshwater fate factors for urban air emissions of 100 year and infinite time horizon (0 - 1.5 orders)



Sea fate factors for urban air emissions of 100 year and infinite time horizon (1 - 5.5 orders)



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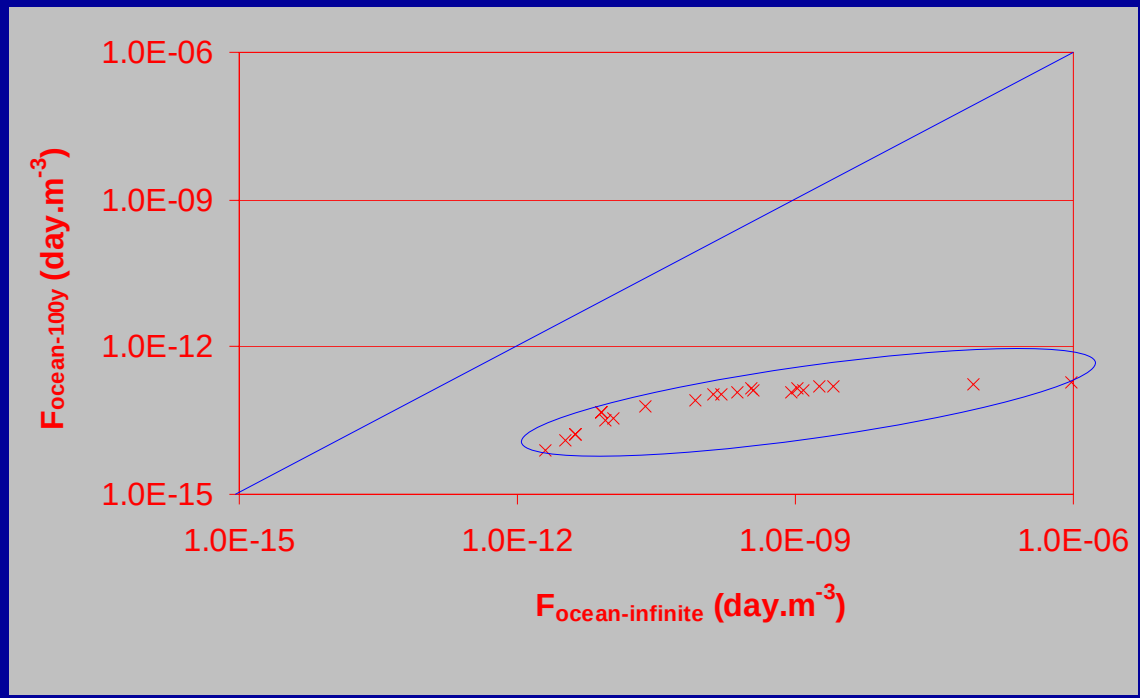
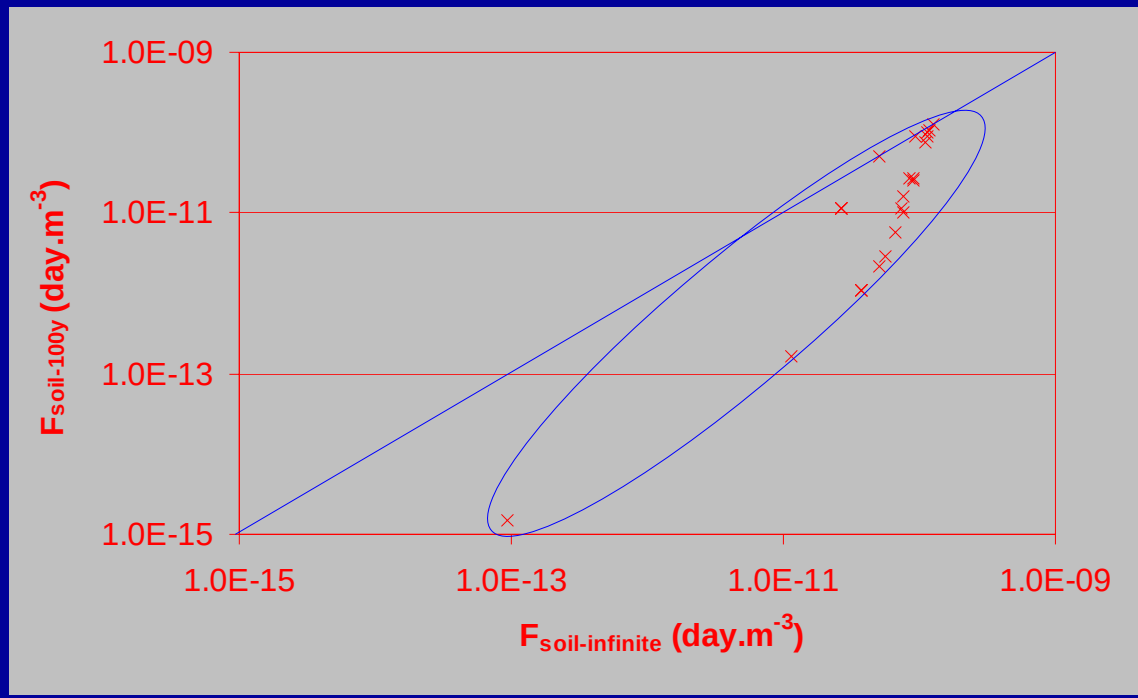
- Results
- Discussion
- Conclusions

Oceanic fate factors for urban air emissions of 100 year and infinite time horizon (2 - 7 orders)



Terrestrial fate factors for urban air emissions of 100 year and infinite time horizon (0 - 2 orders)



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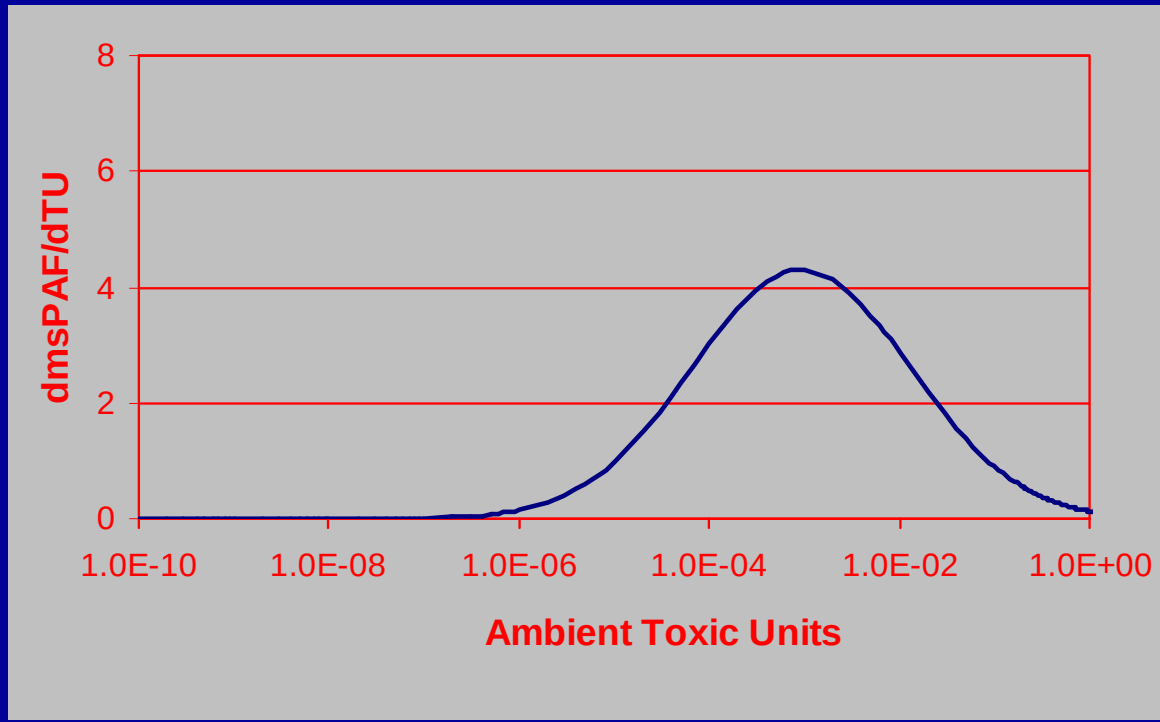
Validity of the metal fate factors

- Partitioning coefficients
- Removal processes:
  - precipitation (e.g. Be)
  - irreversible binding to soil matrix
  - etc.
- Bioaccumulation
- Bioavailibility

Relevancy in relation to marginal effect changes

$$E_x = \frac{\partial msPAF}{\partial C_x} = \frac{\partial msPAF}{\partial TU} \cdot \frac{\partial TU}{\partial C_x} = \frac{1}{\sqrt{2 \cdot \pi \cdot \sigma^2}} \cdot \exp - \left(\left(\log (TU) \right)^2 / \left(2 \cdot \sigma^2 \right) \right) \cdot \frac{1}{\ln(10) \cdot TU} \cdot 10^{-\alpha_x}$$



Conclusions

- Fate factors for metals are sensitive to the choice of a specific time horizon (up to 7 orders)
- Further improvements can be established in several ways (partitioning, removal, bioaccumulation, bioavailibility)
- Relevancy of time horizon dependency in metal fate factors is related to the influence of the ambient situation on the effect factor