ECN experience in calculating emission criteria for construction products

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ECN experience in calculating emission criteria for construction products

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Holzkirchen
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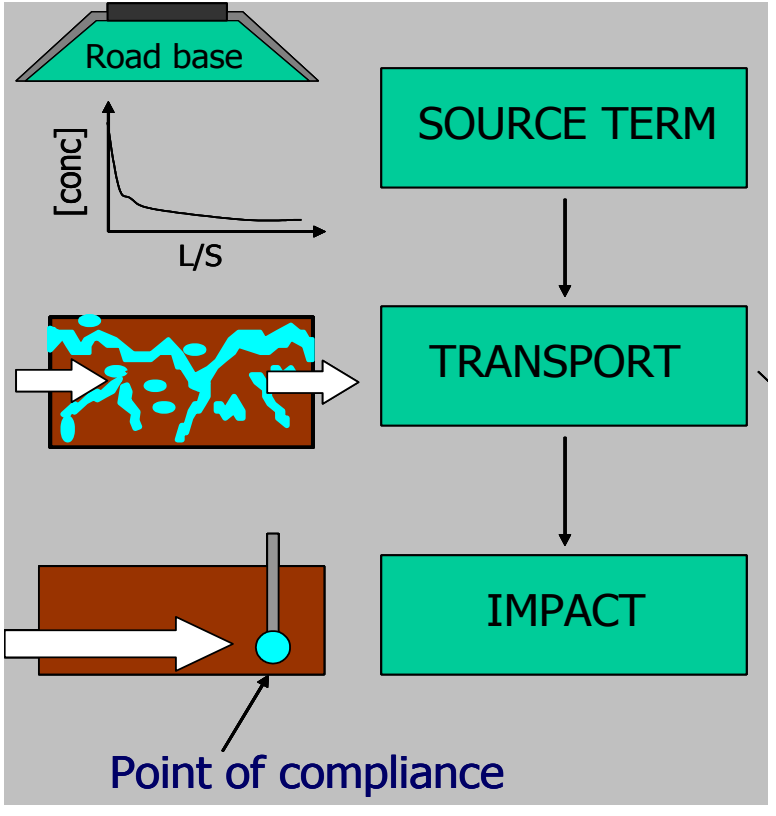
Outline

- ECN Project for IWM – contents and goal
- “Impact assessment”: from test result to release criteria using geochemical models
  - *Example for Construction products in the Dutch Soil Quality Decree (SQD)*
  - *Currently also involved in emission criteria for sustainable landfills, dredged sediments, contaminated soils in deep lakes.*
- How can we use these models to evaluate release from mortars?

Testing programme IWM mortars – ECN project

- Phase 1: pH dependence tests 11 mortars + 2 tank tests
  - Assessment changes of release as a result of different uses & conditions
  - How will release from “fresh product” change due to “ageing” (relevant for CPR)?
  - How will release develop in the recycling / “ end of life” phase (relevant for CPR)?
  - Interlab- validation tank tests (Fraunhofer IBP/ECN; 2 samples)
- Phase 2: Consistency in release data sources
  - pH dependence tests <-> tank tests (Fraunhofer)
  - Improved understanding tank tests and field tests (Fraunhofer)
  - Consistency data sources, relationship between field tests and tank tests
- Phase 3: Impact assessment modelling
  - Potential effects of released substances on the quality of groundwater
  - Reactive transport model developed by ECN substance transport in soils
  - Used for calculating emission limits for construction products in NL

From release to “impact”



Soil Quality Decree

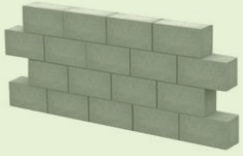
- Follow up of “Bouwstoffenbesluit” (1999-2007);
- Covers new construction products AND recycled products;
- *Generic* limit values for release by leaching: covers products in all intended uses;
- 2 scenario’s for granular constructions, 1 scenario for monolithic constructions.

- Percolation (column) test NEN7373 (~ TS 3 of CEN/TC 351)
- Monolith leach test NEN7375 (~TS 2 of CEN / TC 351)

	Monolithic	Granular, open	Granular, closed
Parameter	Vormgegeven (E_{64d} in mg/m²)	Niet-vormgegeven (mg/kg d.s.)	IBC-bouwstoffen (mg/kg d.s.)
antimoon (Sb)	8,7	0,16	0,7
arseen (As)	260	0,9	2
barium (Ba)	1.500	22	100
cadmium (Cd)	3,8	0,04	0,06
chroom (Cr)	120	0,63	7
kobalt (Co)	60	0,54	2,4
koper (Cu)	98	0,9	10
kwik (Hg)	1,4	0,02	0,08
lood (Pb)	400	2,3	8,3

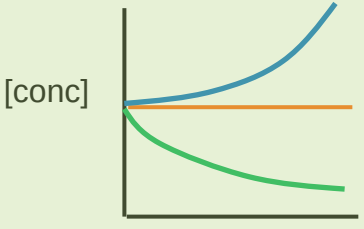
EPA, Industry, Ministry, Local government:

- Boundary conditions, limit values groundwater, which substances, which soils
- Time frame, position point of compliance



"Source term"

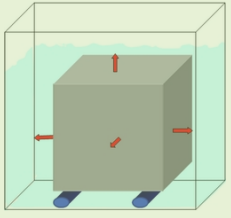
1



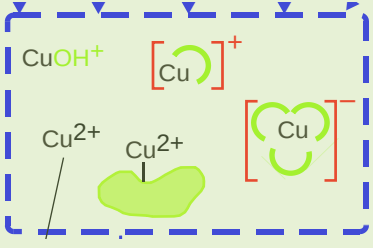
2

Scenario-specific factors (rainfall, position, etc.)

release criterion (e.g., leaching test)



Speciation & transport models



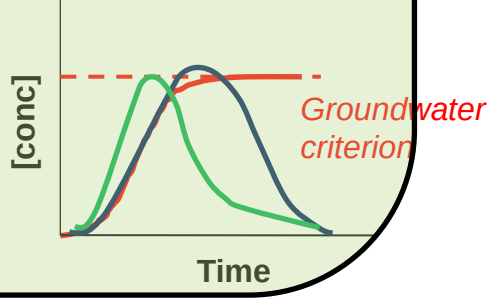
Soil-specific factors (pH, organic matter, etc)

Hydrology, dispersion, dilution

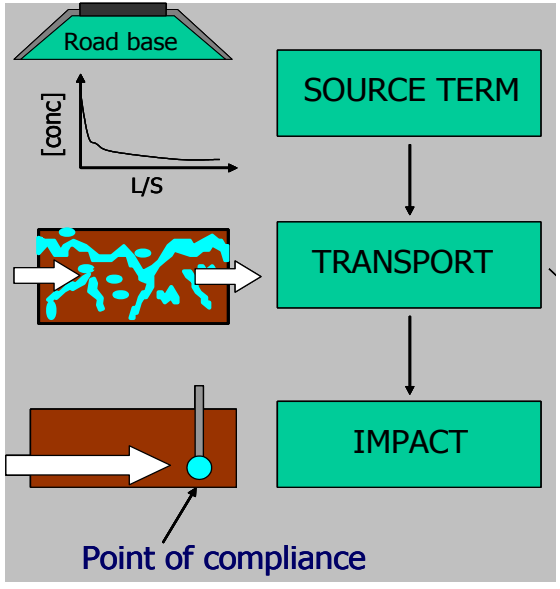
3

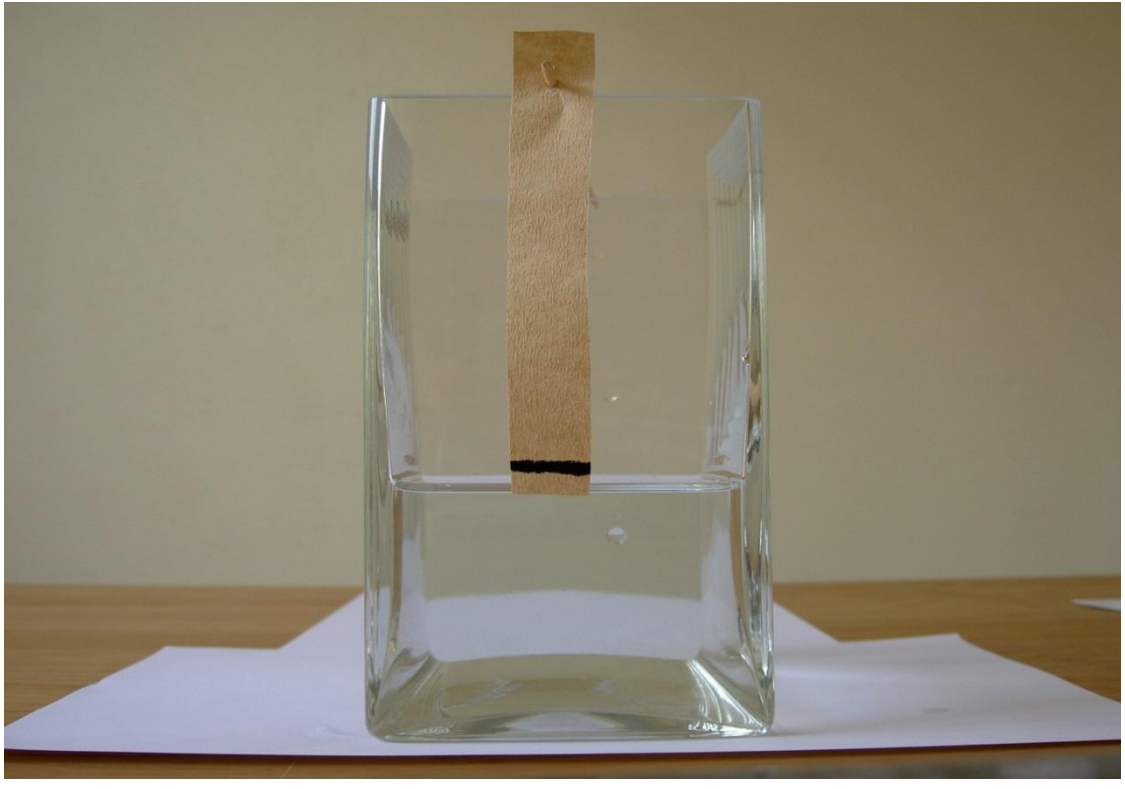
Iterations until concentration at POC meets groundwater criterion

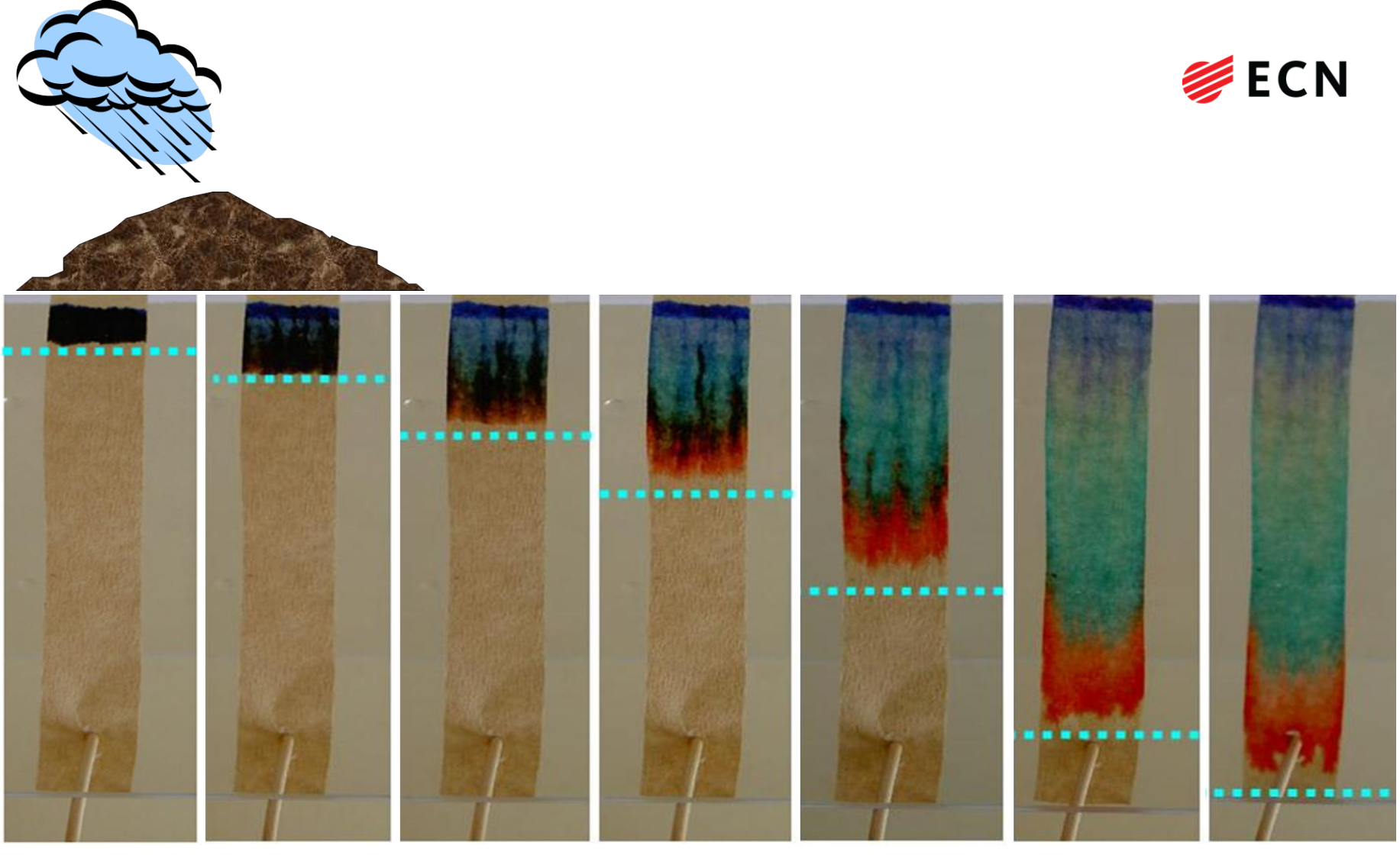
4



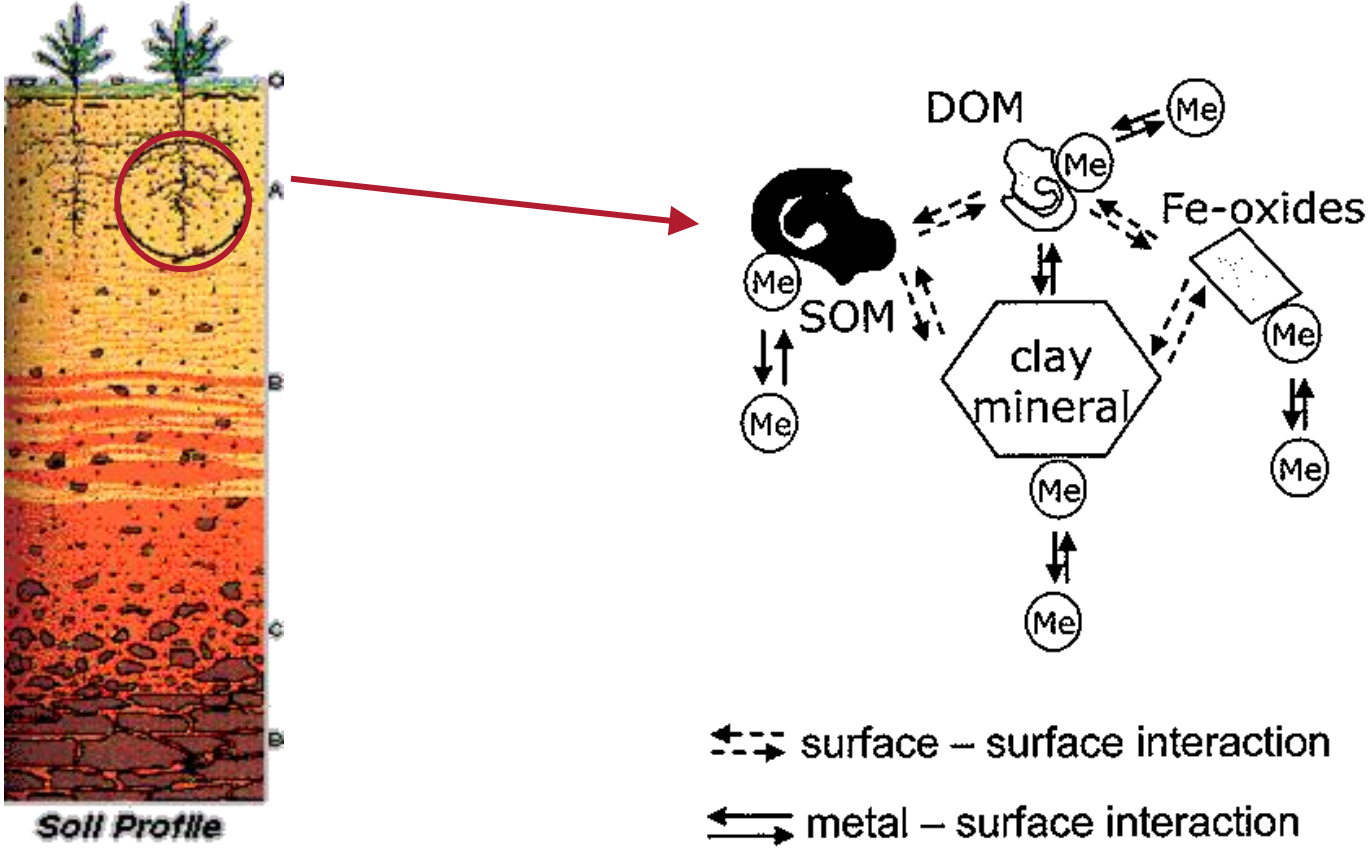
Substances travel with different velocities





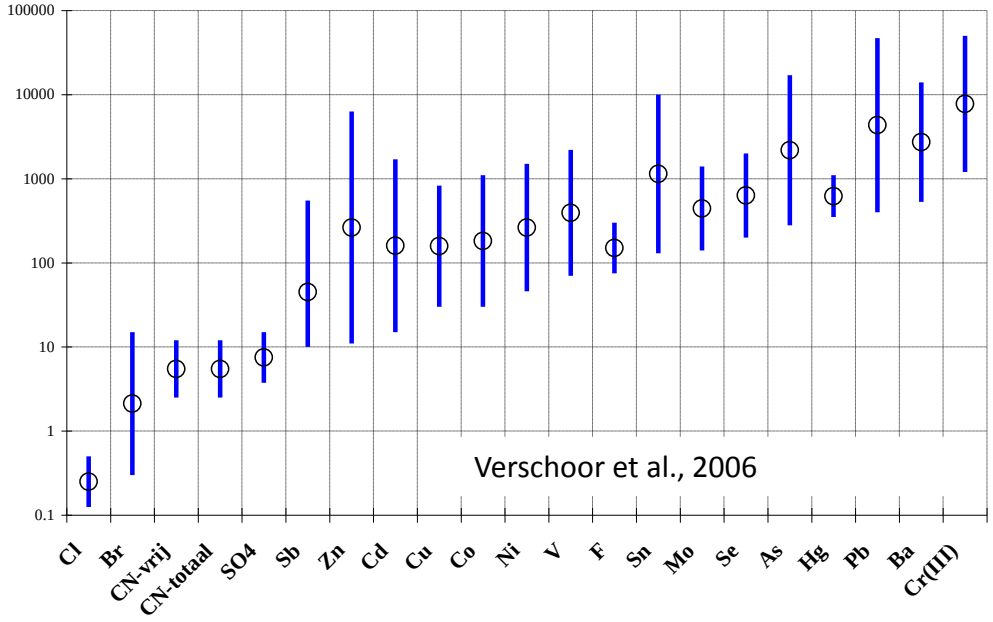

Time

Geochemical processes controlling fate of (leached) contaminants



Sources: Surface and Aqueous Geochemistry Group, Stanford, USA; PhD Thesis Ellen Fest (2007)

….Problem: too large range in Kd values…



- Too large range Kd values, but it greatly determines the outcome.
- Kd approach is too simple for sorption of inorganic substances in soils (non-linearity, pH, competition,..).
- In NL, the Ministry, Industry and EPA, have together chosen for the “Multisurface” Approach to model sorption processes (Soil Quality decree, SQD)

- *Multisurface approach: actual processes, generic validity across many conditions (pH dependency, competition for sorption sites, ..), semi “mechanistic”;*
- *Multisurfac approach: available in common “geochemical models”, e.g., Phreeqc, Visual Minteq, Orchestra.*

“Multi-surface”modelling approach developed at ECN

Major ion chemistry:
pH, major (competing) ions, inorganic ligands
(NIST-thermodynamic database)[1]

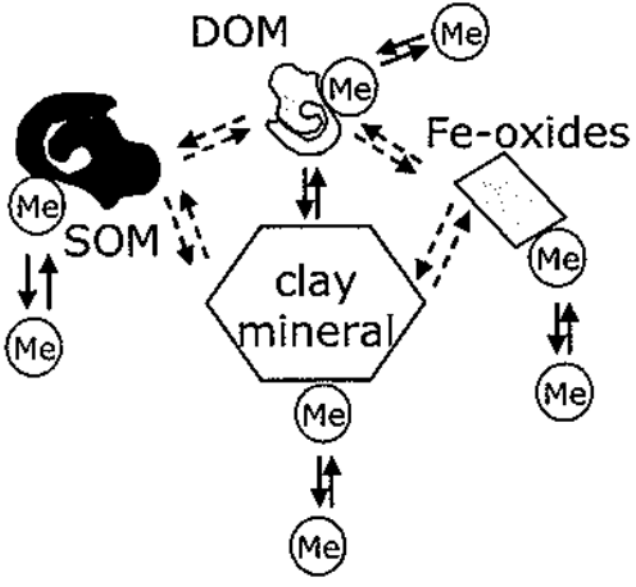
Dissolved organic matter:
Humic and fulvic acids
(NICA model)[2]

Sorbing surfaces in the solid phase:
- OM (humic/fulvic acids)

(NICA model)[2]
- Fe/Al (hydr)oxides

(Two layer SCM)[3]
- Clay particles

(Donnan model)



Implemented in ORCHESTRA[4]

Validated for natural & contaminated soils[5,6]

[1] MINTEQ 4.0/NIST; [2] Milne et al. (2003); [3] Dzombak & Morel (1990); [4] Meeussen (2003); [5,6]Dijkstra et al (2004, 2009)

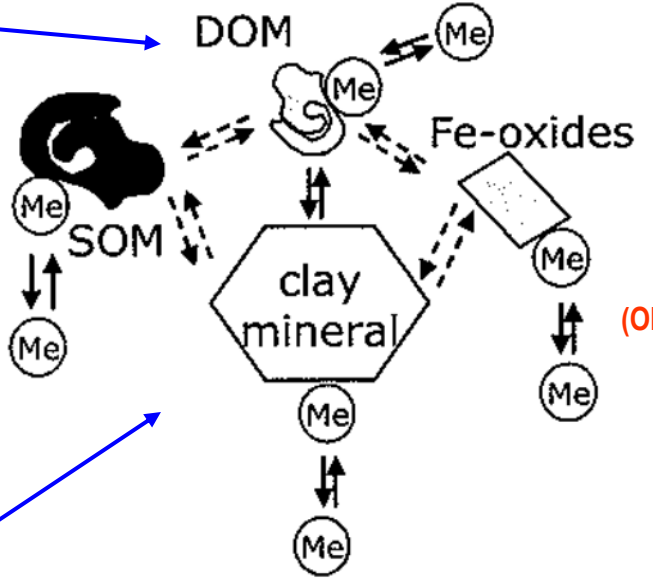
Model parameterization

Dissolved organic matter:
→ Humic and fulvic acids*
ISO 12782-5

"Available" concentrations:
→ Leaching at low pH (≈0.4)
(ISO 21268-4)

Reactive surfaces in the solid phase:
→ SOM (humic/fulvic acids)*
ISO 12782-4

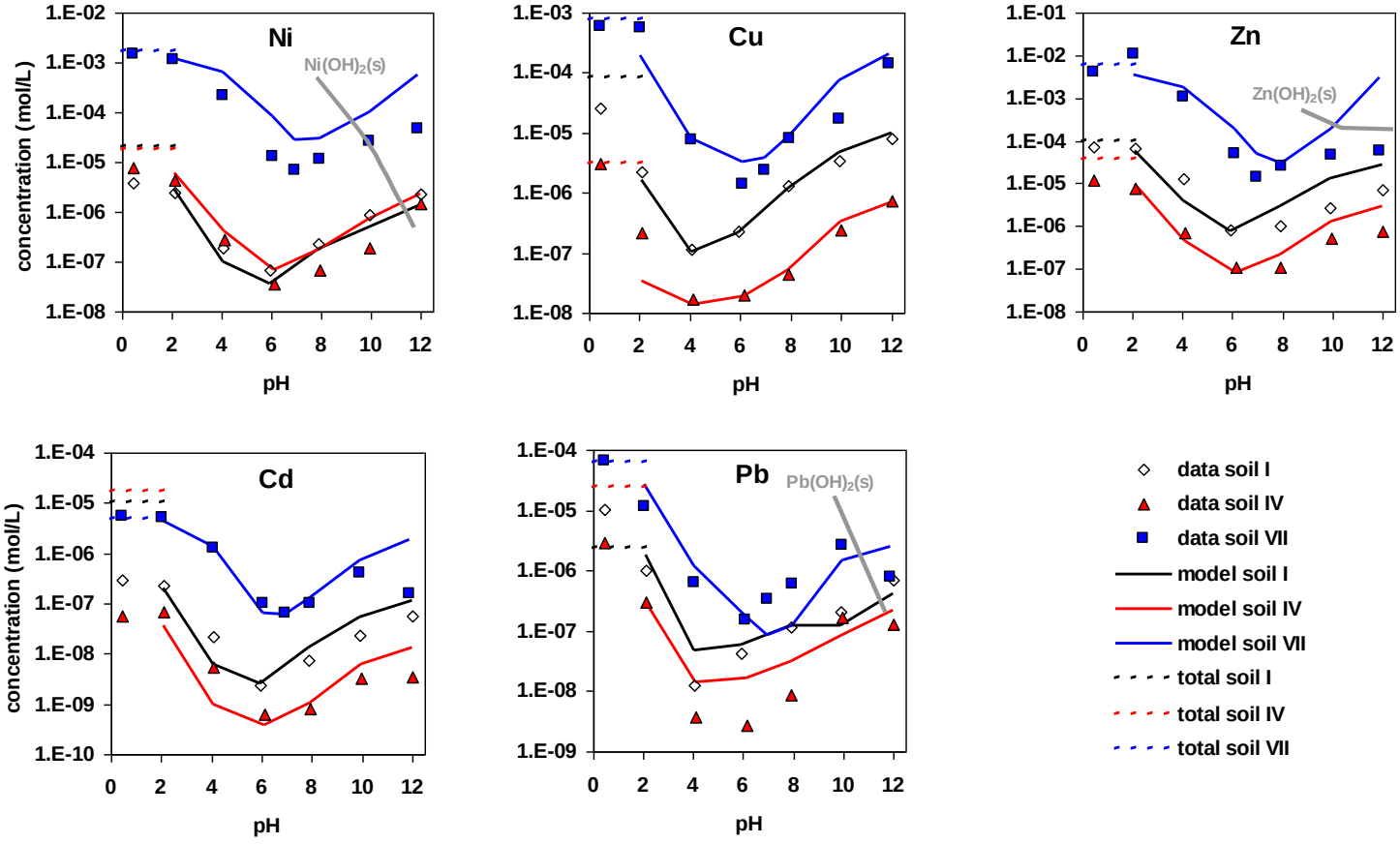
→ Fe/Al (hydr)oxide minerals
ISO 12782-1 (Fe_{am})
ISO 12782-2 (Fe_{cryst})
ISO 12782-3 (Al_{am})



(ORCHESTRA)

Guideline for modelling
→ New Work Item ISO/NP 19648 accepted

Validation of the “multisurface” model approach



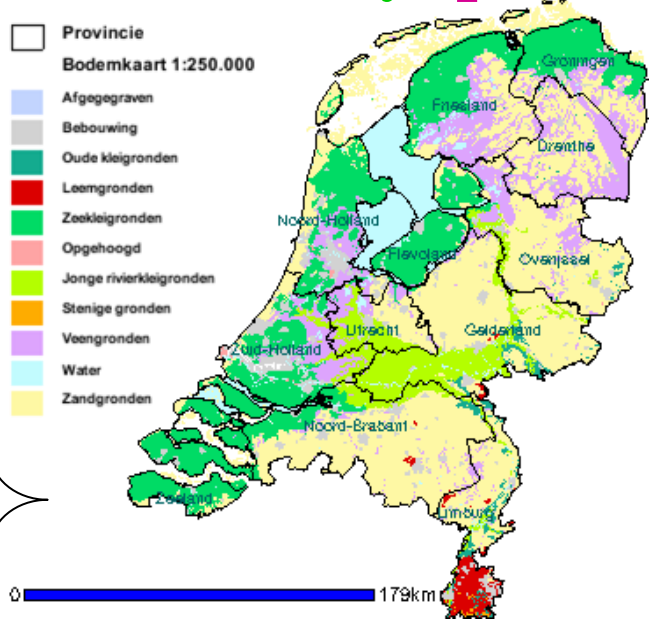
Natural and industrially contaminated soils.

Dijkstra et al., *Environmental Science and Technology* (2004), 38, 4390-4395

Dijkstra et al., *Environmental Science and Technology* (2009), 43, 6196-6201

Transport in SQD calculations: representative soils in the Netherlands

sand, clay, peat

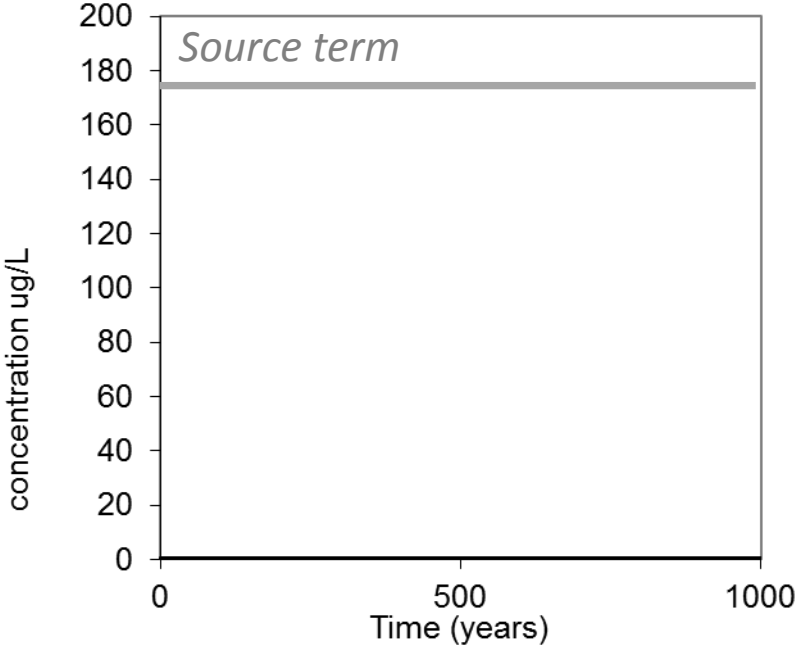


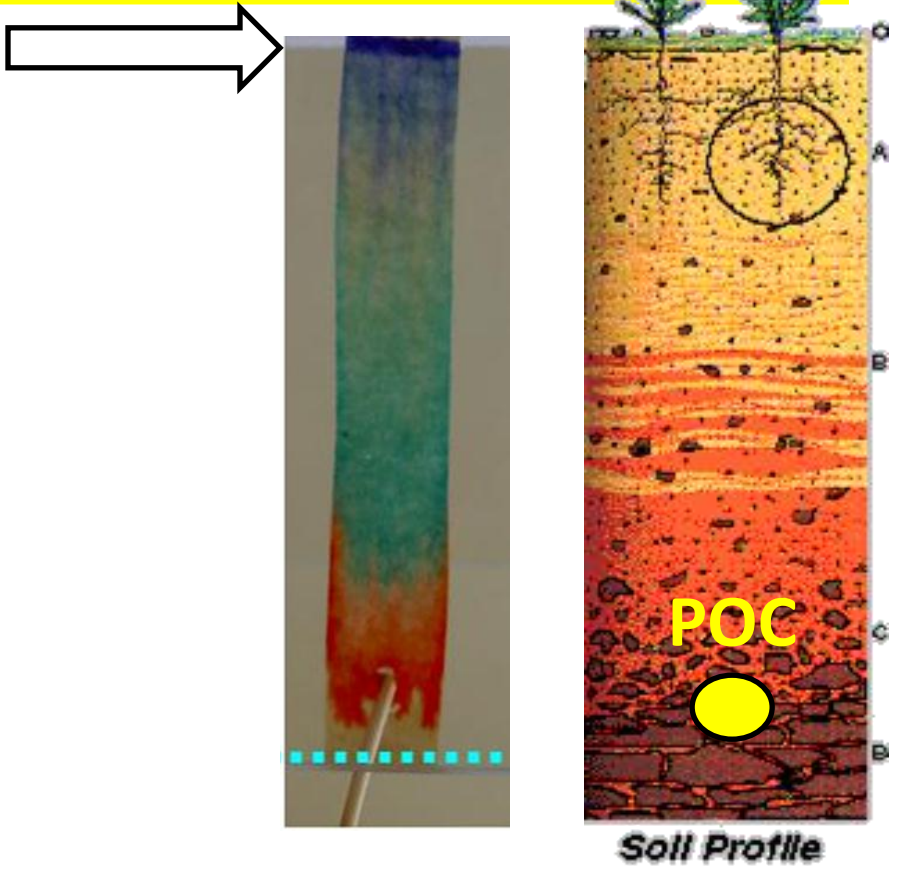
Stone database (Alterra)

Specific depth profiles:

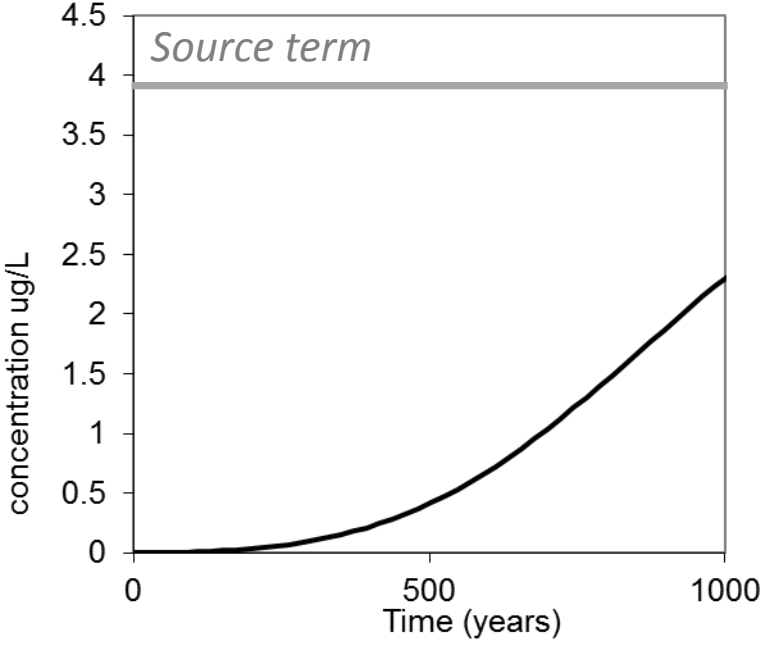
- ***pH***
- ***Reactive mineral/ -organic surfaces***
- ***Hydrological properties***

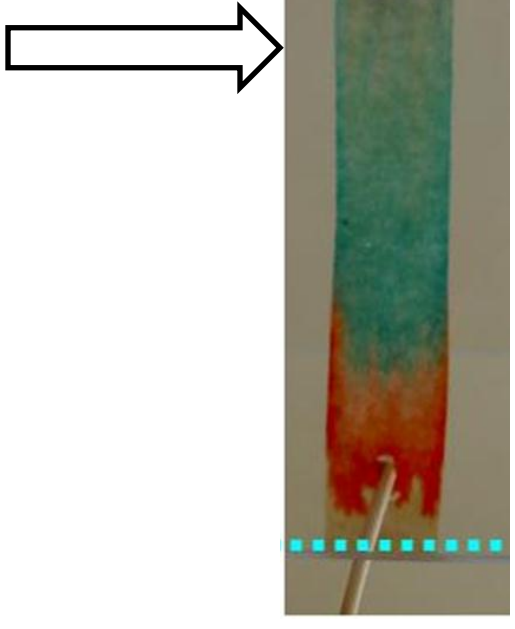
Effect of retardation



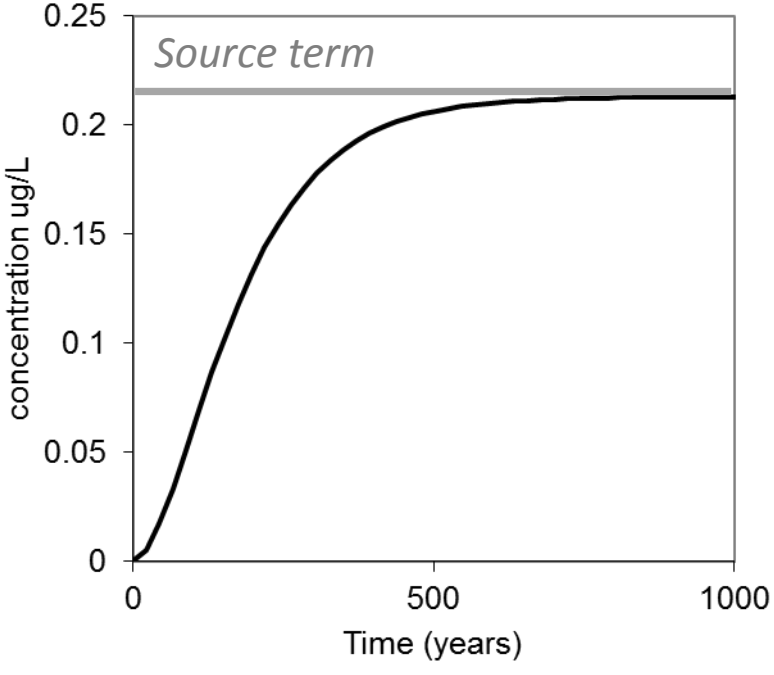


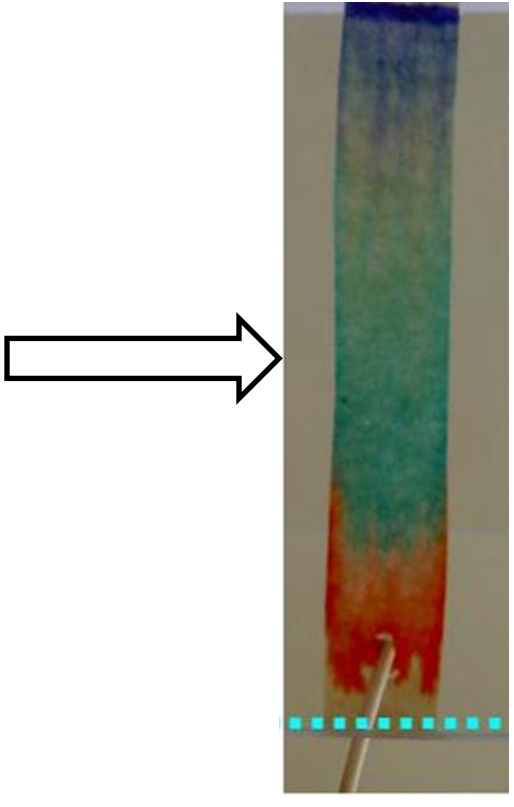
Effect of retardation





Effect of retardation





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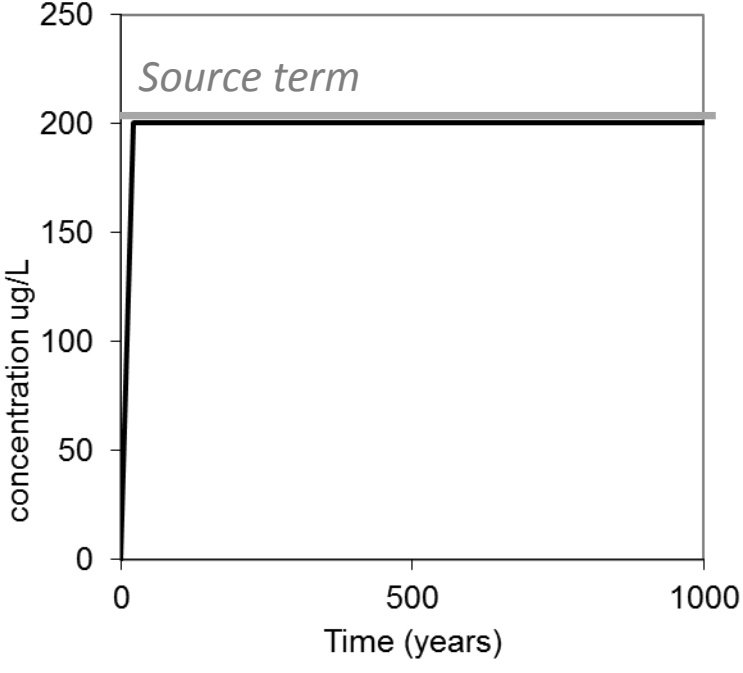
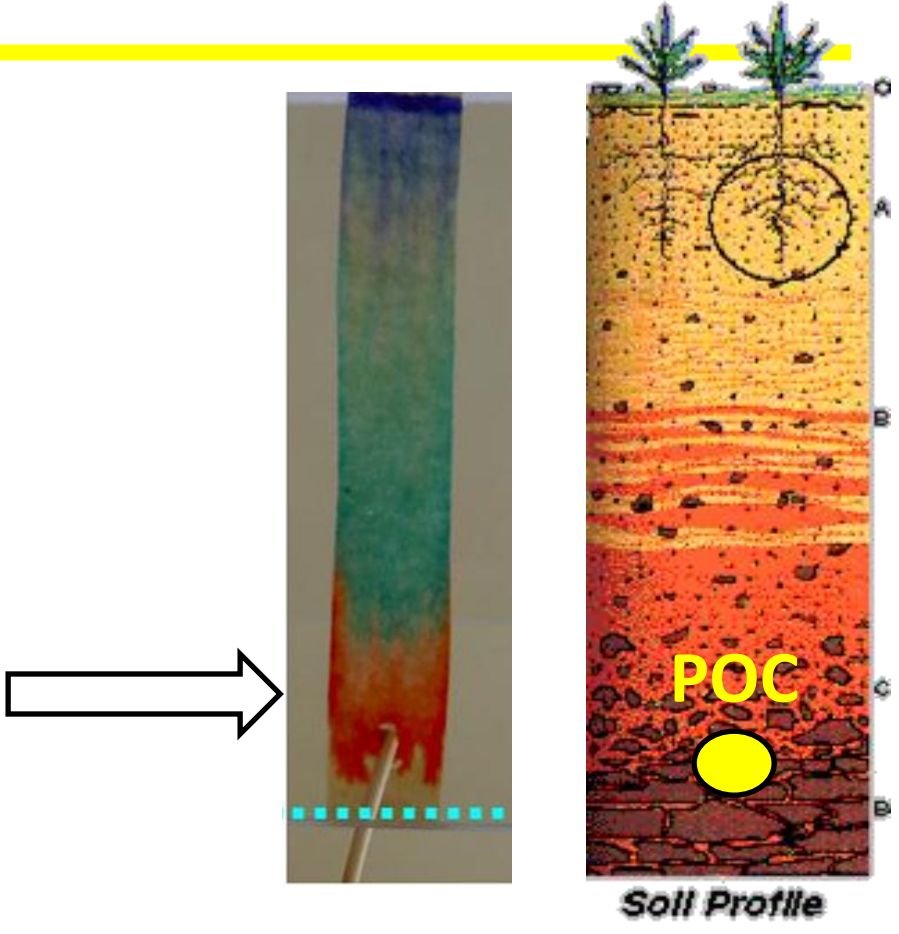
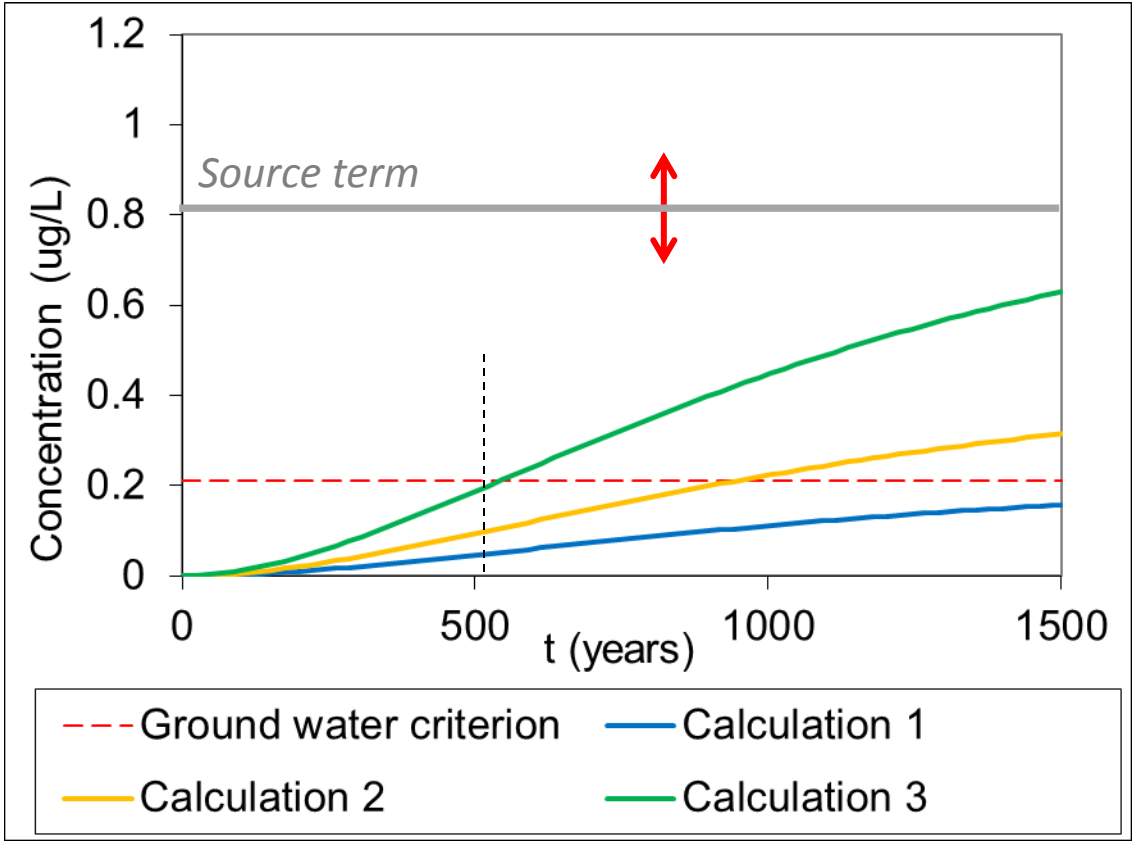


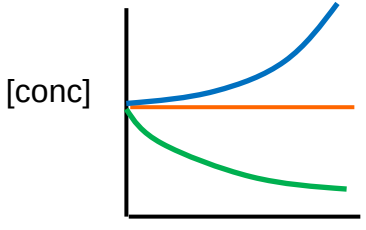


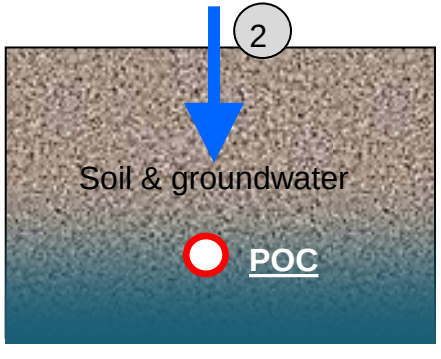
Establishing a release criterion

Example: time frame 500 years



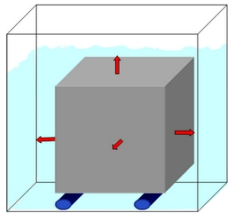
"Source term" 1



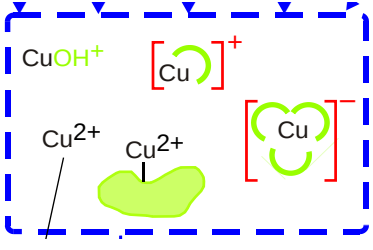


Scenario-specific factors (rainfall, position, etc.)

release criterion (e.g., leaching test)



Speciation & transport models

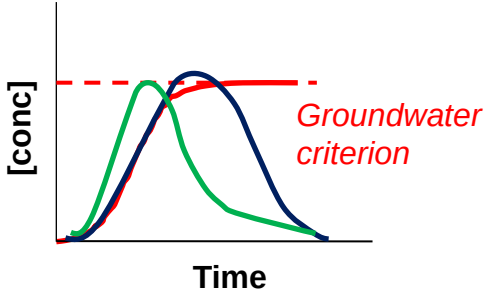


Soil-specific factors (pH, organic matter, etc)

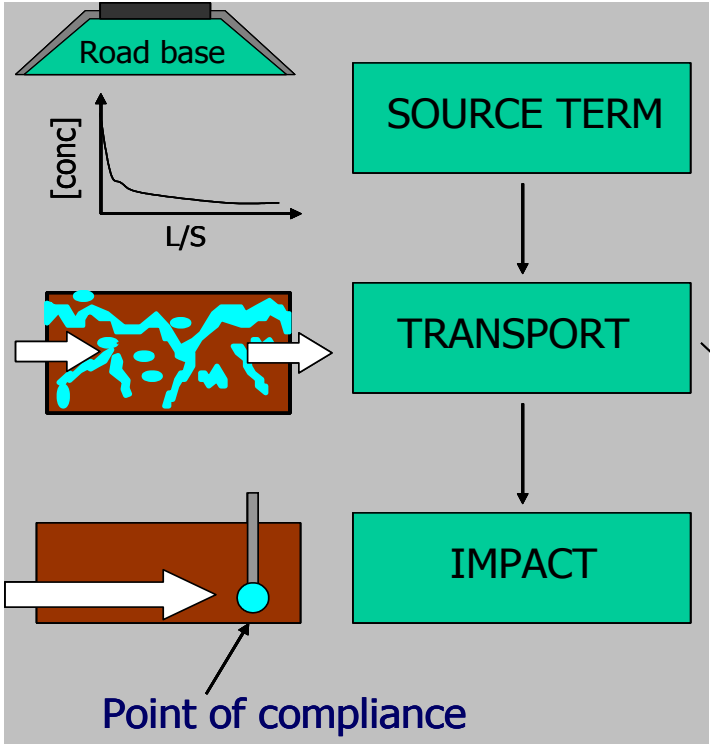
Hydrology, dispersion, dilution

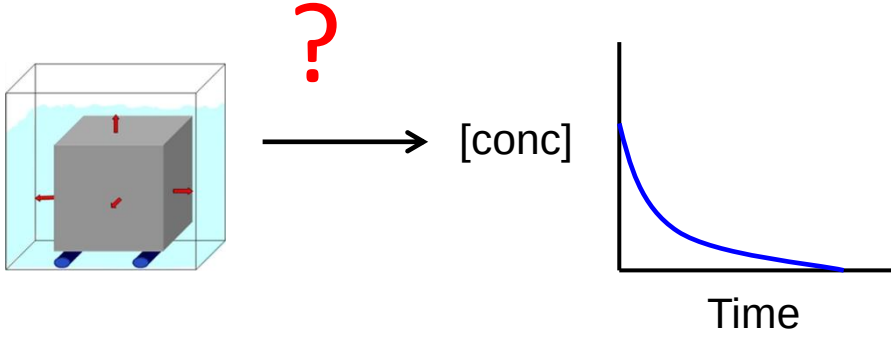
3

Iterations until concentration at POC meets groundwater criterion 4

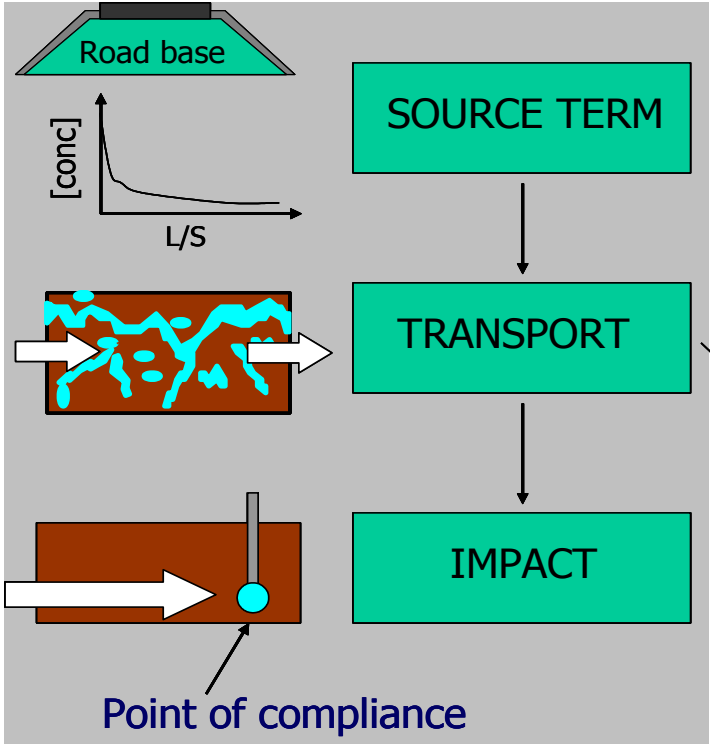


How can we use this knowledge for *specific* impact assessment?





How can we use this knowledge for specific impact assessment?



Example:

- Enter specific source term(s) in SQD model;
- Enter specific soil(s) in the SQD model.

Model development

Accessible model tools and applications

LeachXS: database expert system (ECN, Vanderbilt University, DHI)

- LeachXS Lite (free license, developed mainly for US-EPA)
- LeachXS Pro (License fee);

- Databases with > 10000 results of leaching tests, > 1000 materials
- Tools for interpretation, regulations, statistics, plotting, reporting
- Tools for modelling; *contains Soil Quality Decree scenario*

LeachXS™

A database/expert decision support system for characterization and environmental impact assessment

L E A F

LeachXS™ Developer Version

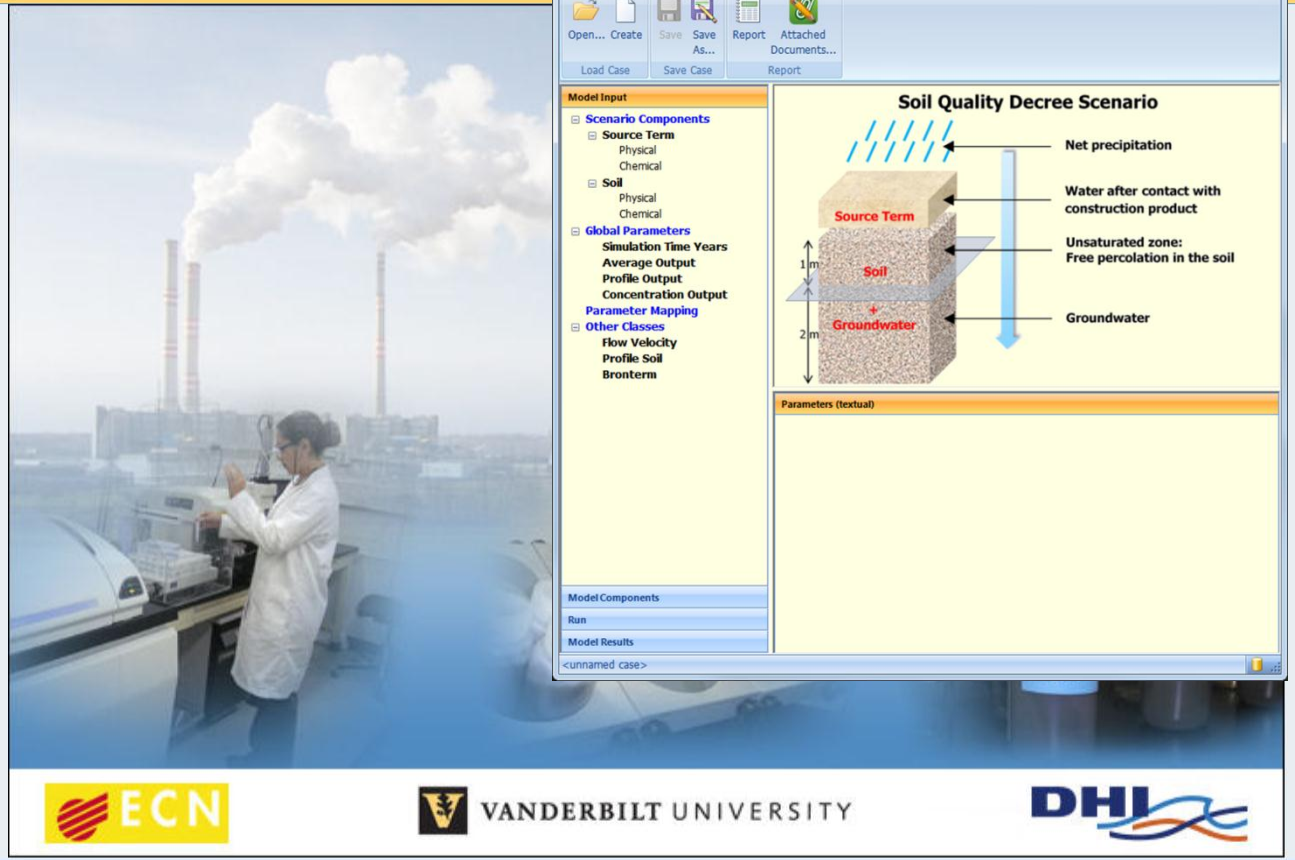
Database | Export | Tools | Version | Help

Current database:
...\ECN cement, mortar and concrete leachingdbase.mdb
Select other database...
Database

Material references
Verification

Welcome

Assistance



Analyze, Compare, and Display Leaching Data
Acid/Base Neutralization Capacity
Import or Add New Data
Classic LeachXS Modeling
Advanced Modeling

EN 13:57 3-11-2014

Thank you for your attention!

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