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ASSESSING RISKS OF CHEMICALS

Application of improved scientific approaches in support of risk assessment within the European REACH and Biocides Regulations: A case study on metals

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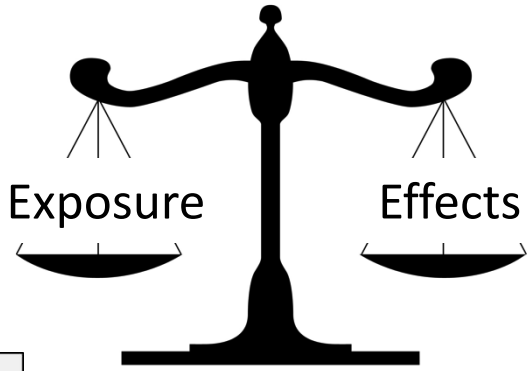
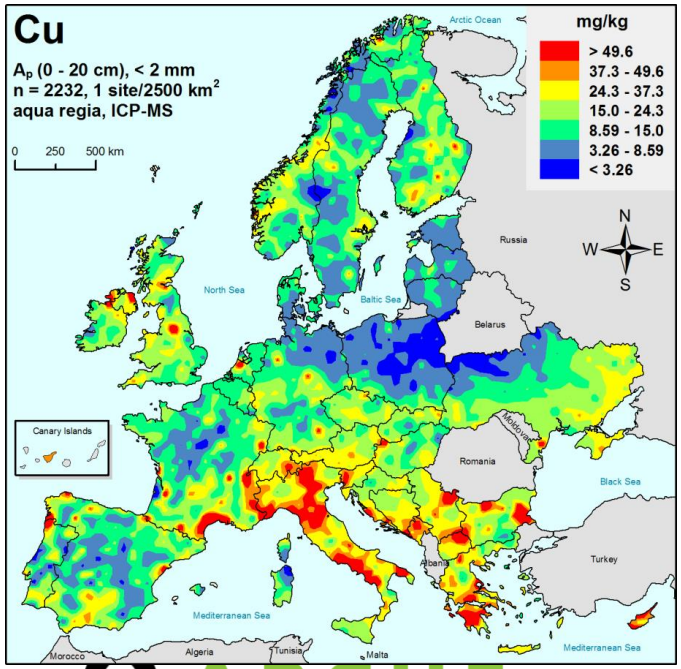
Topical Scientific Workshop on
Soil Risk Assessment
Helsinki, 8 October 2015

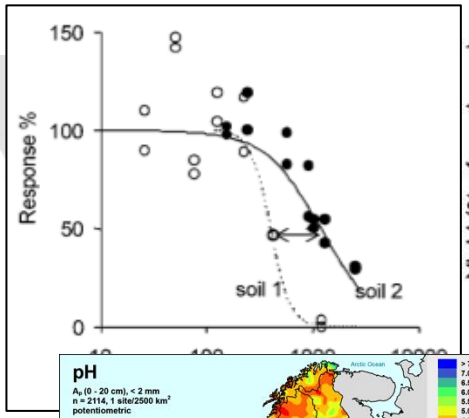
Risk assessment of metals in soil

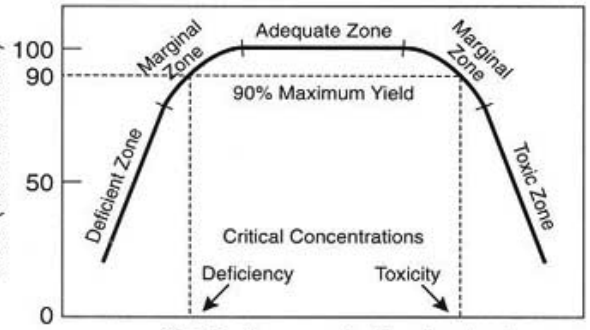
- Spatial variation of natural background

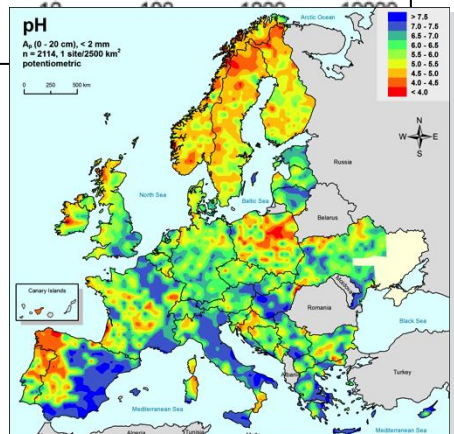


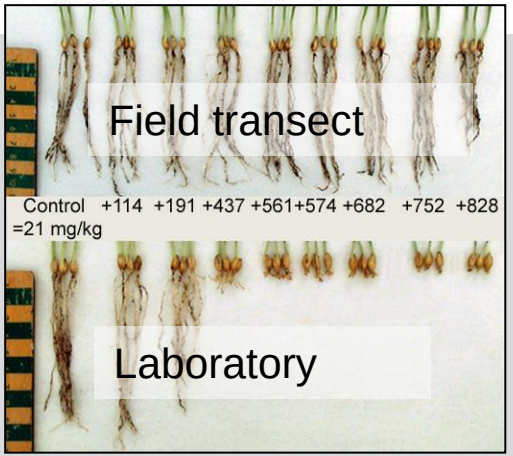
- Spatial variation of soil properties
- Essentiality
- Difference lab vs field conditions











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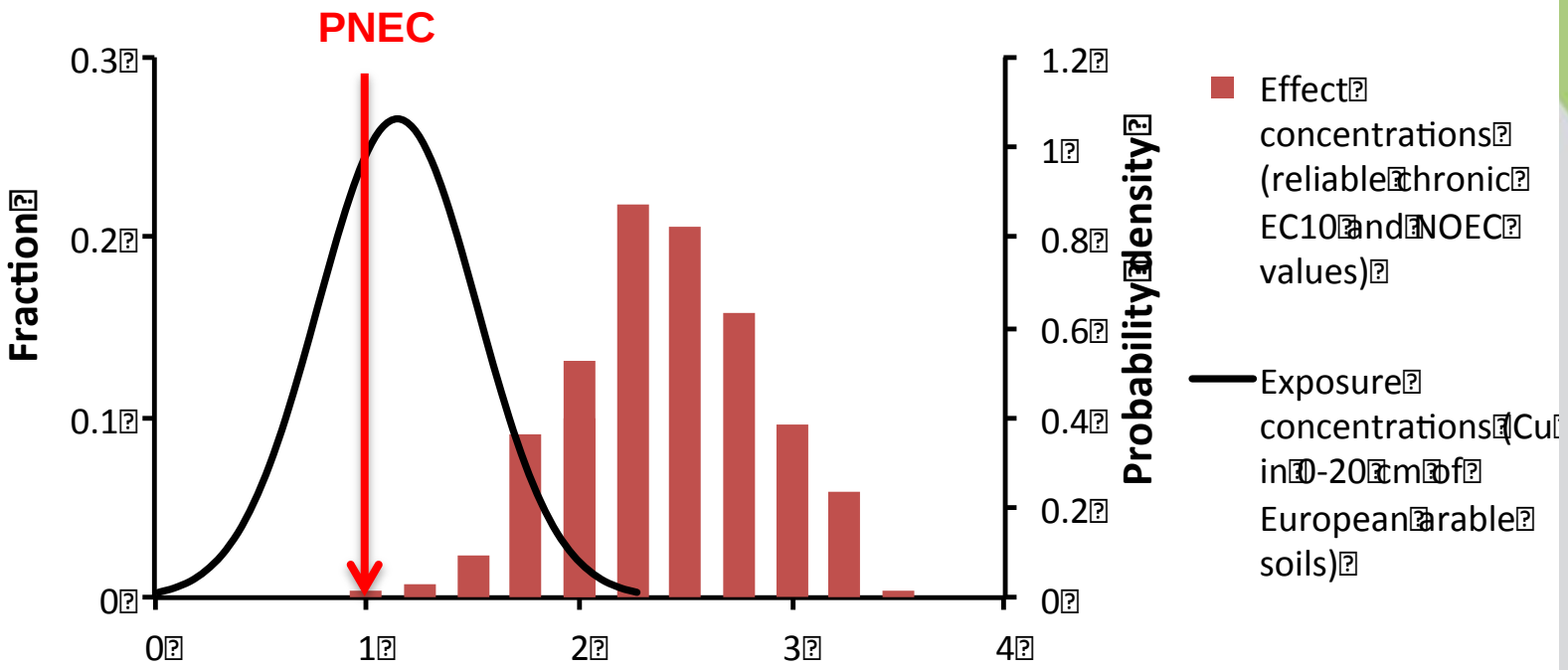
Risk assessment of metals in soil



With standard approaches: PNEC within range of background concentrations for Cu

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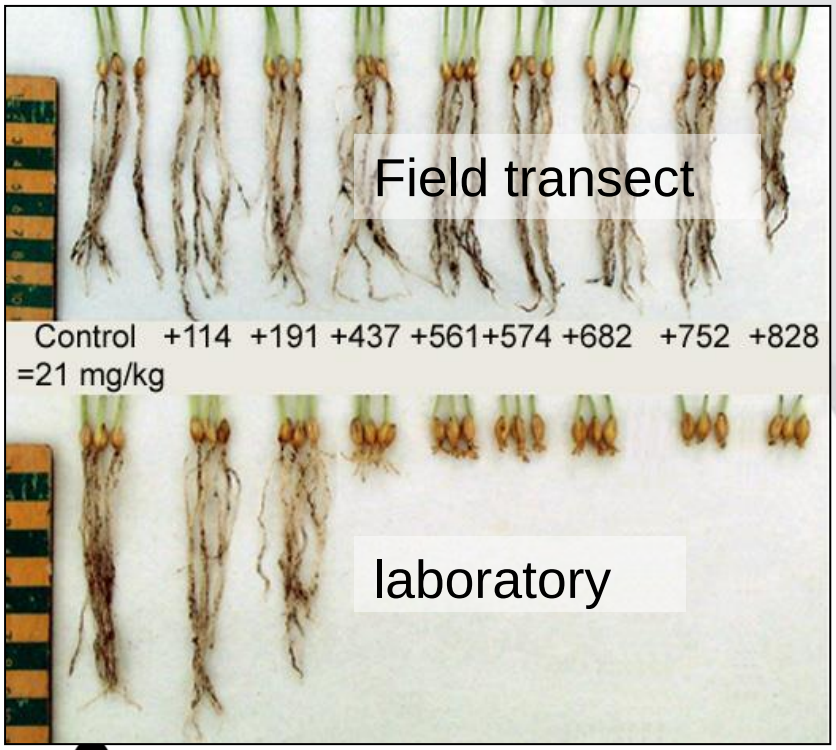
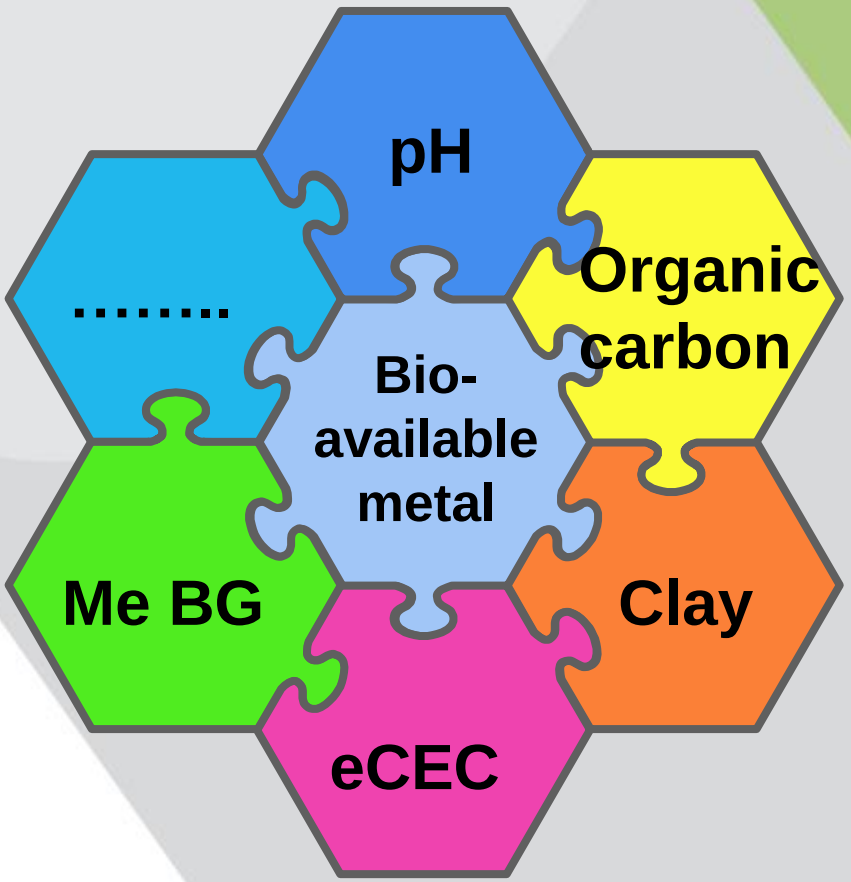
Bioavailability corrections

Correction for differences in **lab-field conditions**



Correction for differences in **soil properties**



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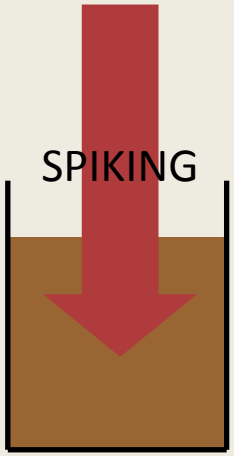
Differences in lab-field conditions

Lab conditions



- Sudden disturbance
- No long-term equilibration
- Increased ionic strength and decreased pH

Field conditions

- Gradual accumulation
- Ageing reactions
- Excess ions leached out

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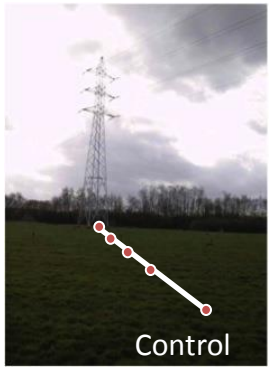
Lab-to-field correction factor

- Direct comparison of toxicity between freshly spiked soils and corresponding laboratory aged soils or field contaminated soils



Metal	# endpoints x # soils
Cu^{2+}	7 x 7
Zn^{2+}	7 x 4
Ni^{2+}	7 x 3
Co^{2+}	9 x 3
Pb^{2+}	6 x 3
MoO_4^{2-}	10 x 3

- Lab-to-Field (L/F) factor = $$\frac{EC_x / NOEC_{Field\ /\ aged,add}}{EC_x / NOEC_{freshlyspiked,add}}$$

based on added metal concentrations

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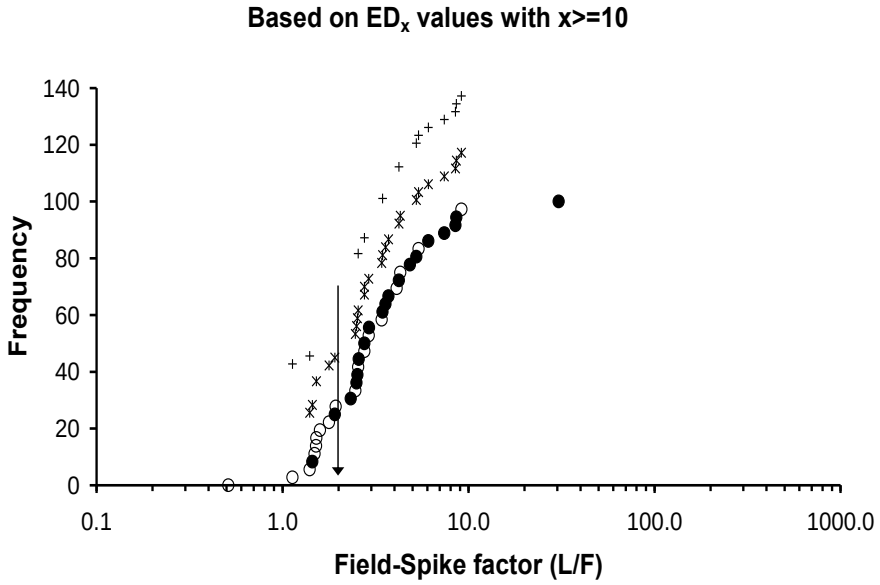
Lab-to-field correction factor

Selection of L/F factor for risk assessment based on weight of evidence:

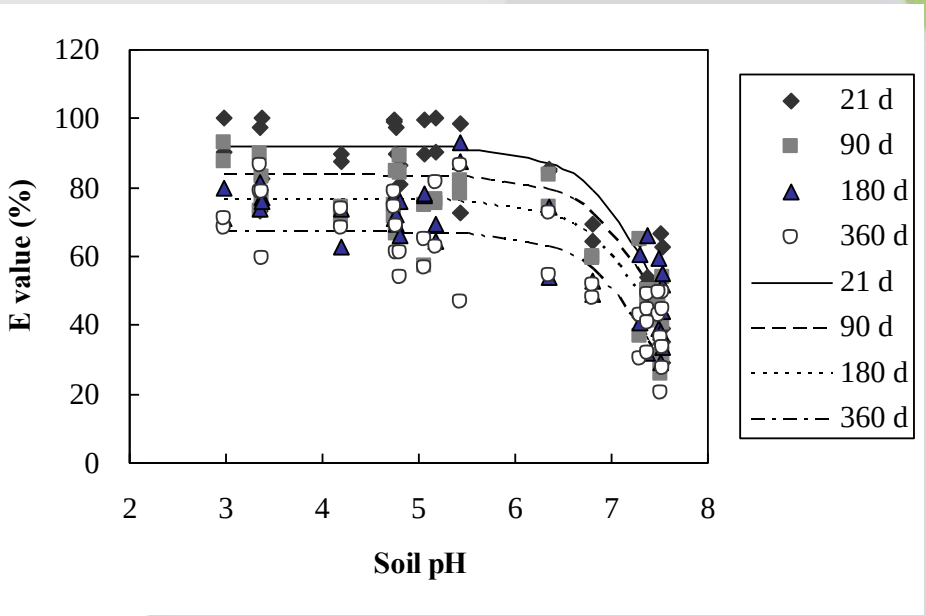
Ecotoxicity

Distributions L/F factors Cu



Soil chemistry

Changes in isotopically exchangeable fraction of Cu with time



Based on Ma et al. 2006. Env. Sci. Tech.

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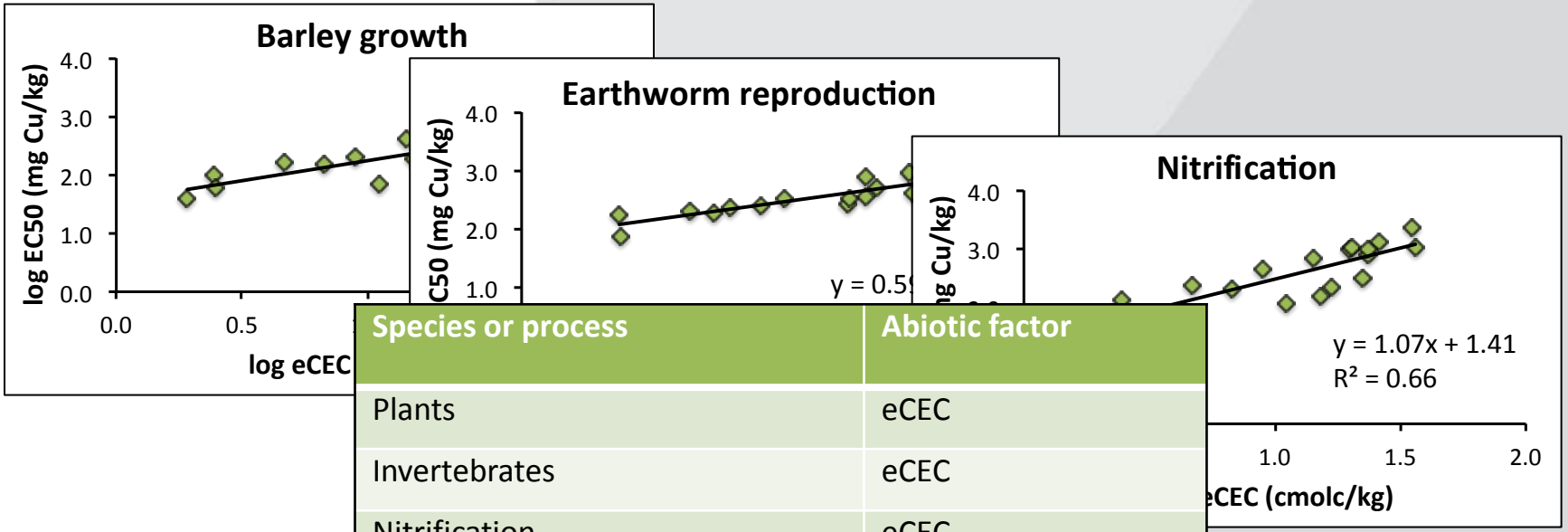
Differences in soil properties

- Comparative chronic toxicity datasets: 6-11 endpoints tested in 8-19 soils
- Toxicity can vary more than 2 orders of magnitude for same endpoint
- Significant empirical regression models between toxicity thresholds for plants, invertebrates and micro-organisms and soil properties (log-log basis)



Species or process	Abiotic factor
Plants	eCEC
Invertebrates	eCEC
Nitrification	eCEC
Glucose respiration	Organic C and clay
Plant residue mineralization	pH and eCEC

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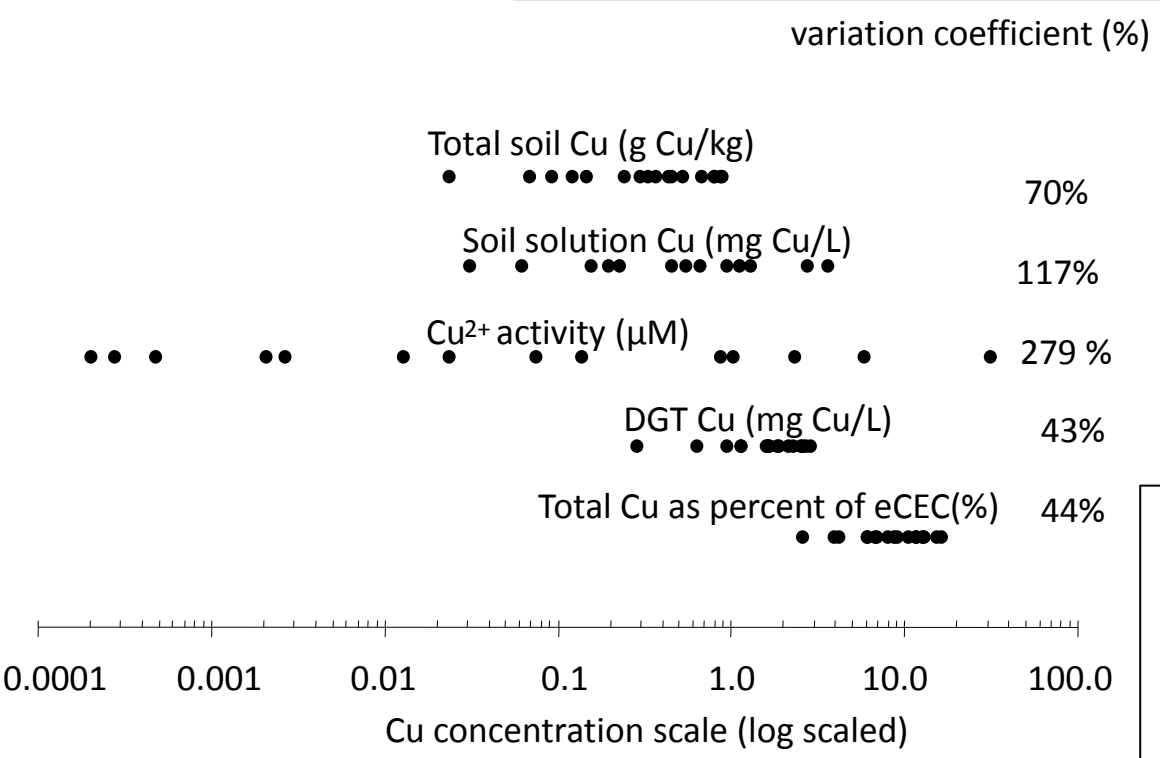
Bioavailable fraction of metals in soil

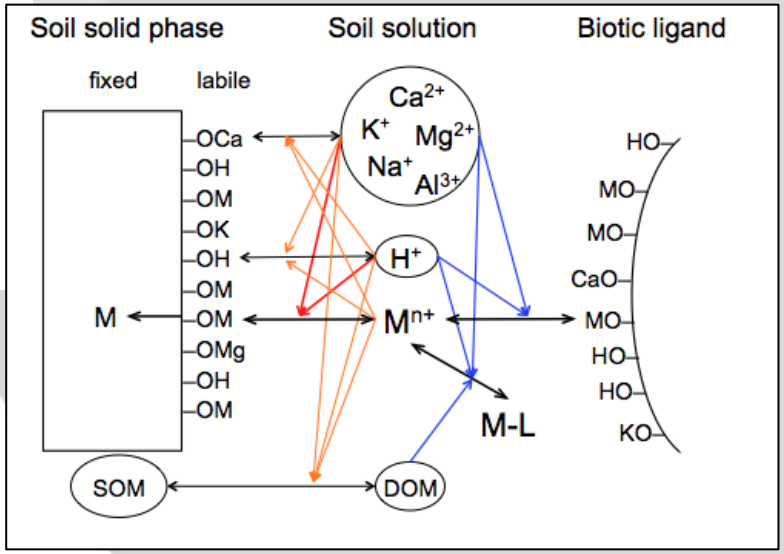
EC_{50} values for toxicity of Cu to tomato shoot yield in 19 freshly amended soils:



Adapted from F. Zhao et al., 2006 Environ. Tox. Chem.

No consistent best estimate for metal toxicity to soil organisms identified

Complexity of mechanistic models too high for use in regulatory framework



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Derivation of $PNEC_{soil}$ under REACH

Selection EC_{10} (or NOEC) values

↓

Correction for differences in toxicity between laboratory spiked soil and field soil conditions

↓

$$EC_{10,field} = EC_{10,added} \times \textbf{L/F factor} (+ C_b)$$

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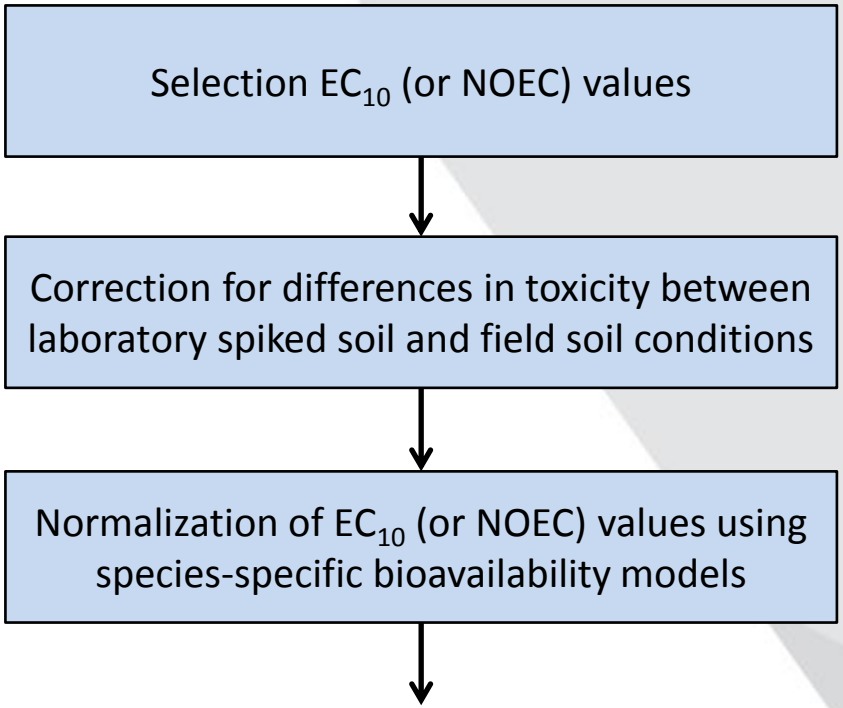
Derivation of $PNEC_{soil}$ under REACH



$$NOEC_{reference} = NOEC_{test}\left[\frac{abioticfactor_{reference}}{abioticfactor_{test}}\right]^{slope}$$

- Reference: scenario for which threshold values must be derived
- Test: abiotic factors of the soil in which the NOEC or EC_{10} was derived
- **Slope: slope of regression equation between log EC_x and log soil properties**

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Derivation of $PNEC_{soil}$ under REACH

Selection EC_{10} (or NOEC) values

↓

Correction for differences in toxicity between laboratory spiked soil and field soil conditions

↓

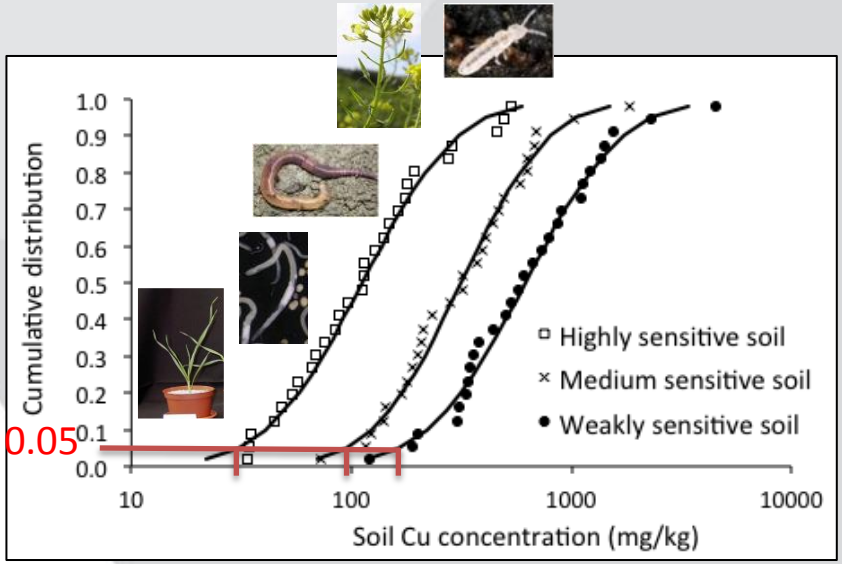
Normalization of $EC_{10,field}$ values using species-specific bioavailability models

↓

Calculation of species mean value for most sensitive endpoint per species

↓

Derivation of HC_5 and PNEC from species sensitivity distribution curve

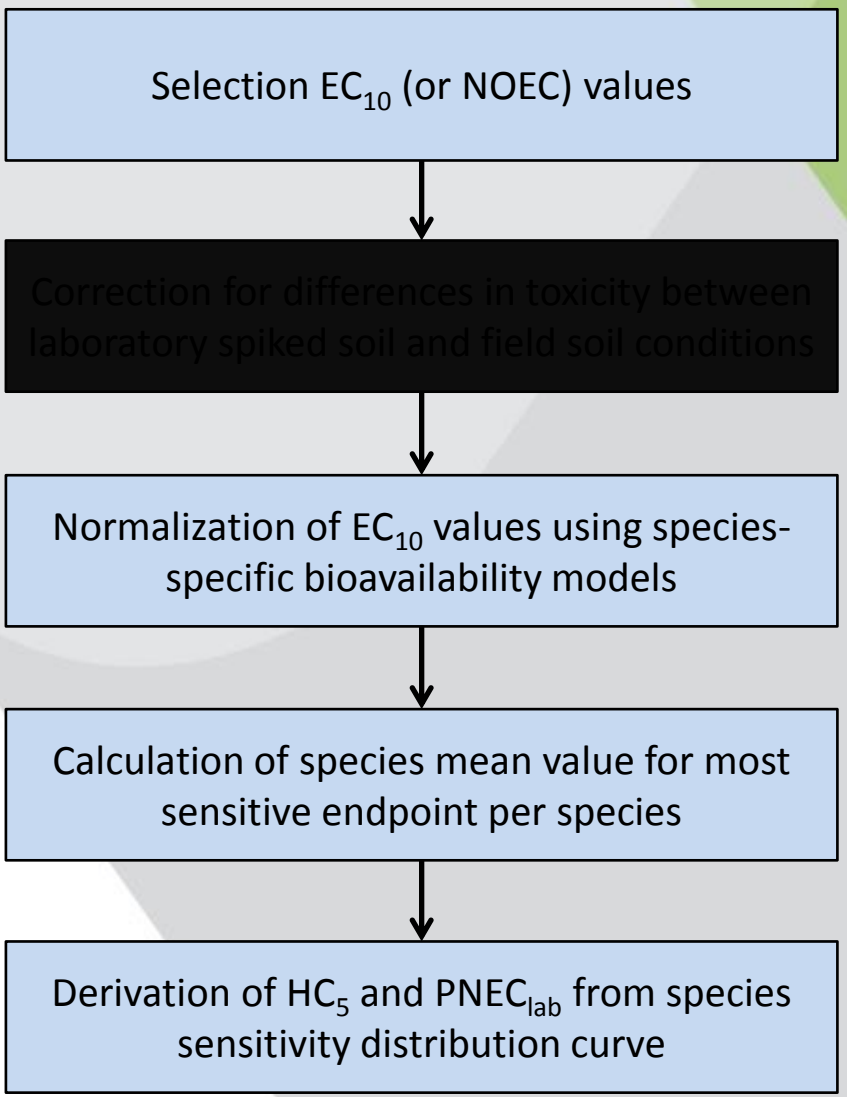


$PNEC = HC_5 / AF$

Derivation of $PNEC_{soil}$ under BPR for Cu

- Toxicity data and bioavailability models same as for Cu REACH dossier
- Only difference:
  Lab-to-field factor not applied on PNEC, but on exposure (PEC)

$$\text{Risk characterization} = \frac{PEC / LF}{PNEC_{lab}}$$



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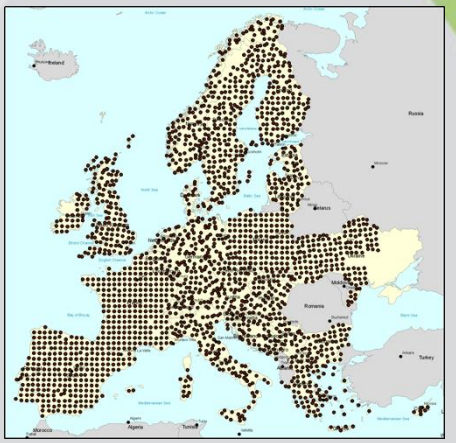
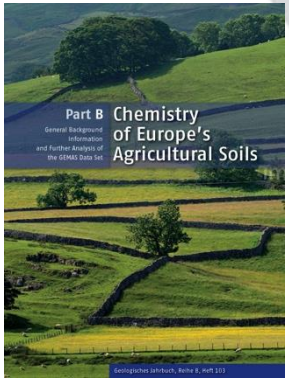
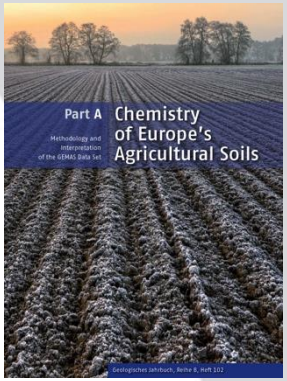
GEMAS: database for optimal regional risk assessment of metals in Europe

- GEochemical Mapping of Agricultural and grazing land Soil
- Carried out by the EuroGeoSurveys Geochemistry Expert Group in cooperation with Eurometaux
- Aim: produce high quality exposure data for trace elements and soil properties across Europe, harmonized with respect to:
  - Spatial scale (homogeneous sampling density)
  - Land-use: arable land (0-20 cm) and grazing land (0-10 cm)
  - Sampling and analytical methodology
- Results published (http://gemas.geolba.ac.at)







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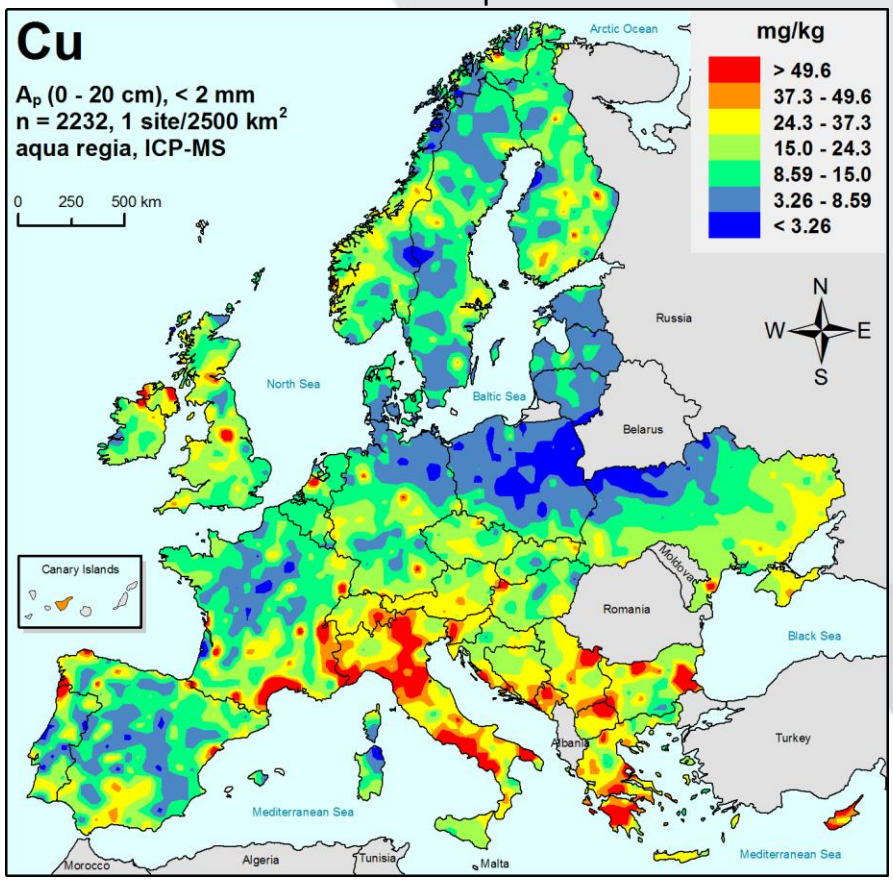
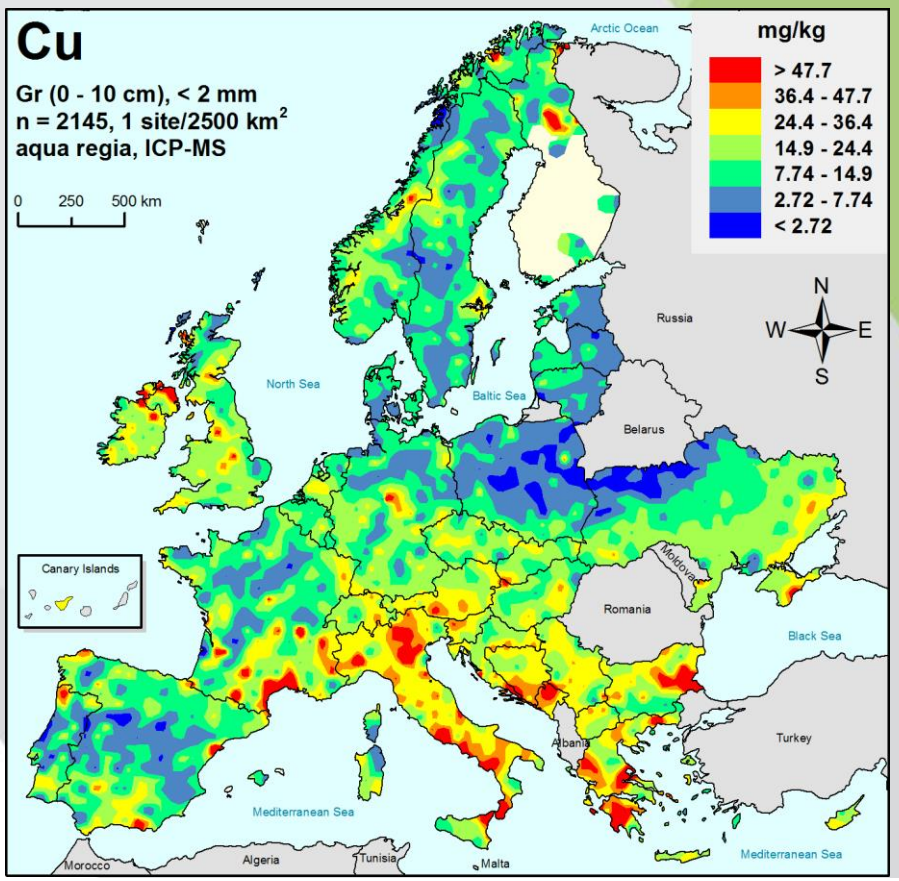
GEMAS: Soil Cu concentrations across Europe

Agricultural soils (A_p) 0-20 cm



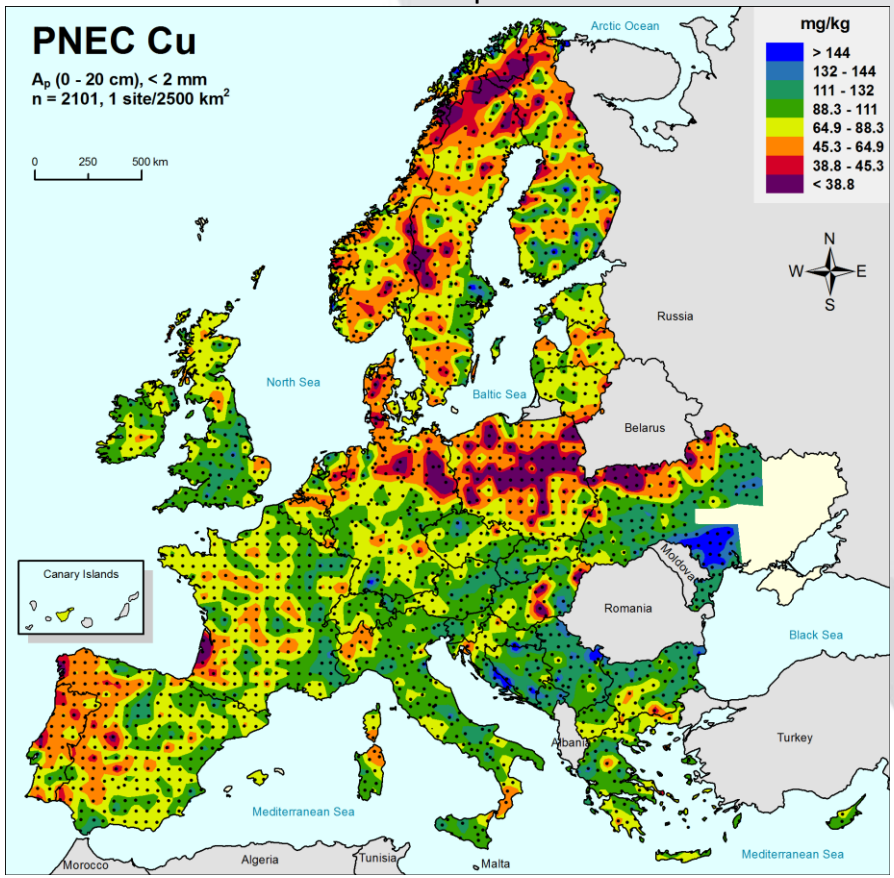
Grazing land soils (Gr) 0-10 cm



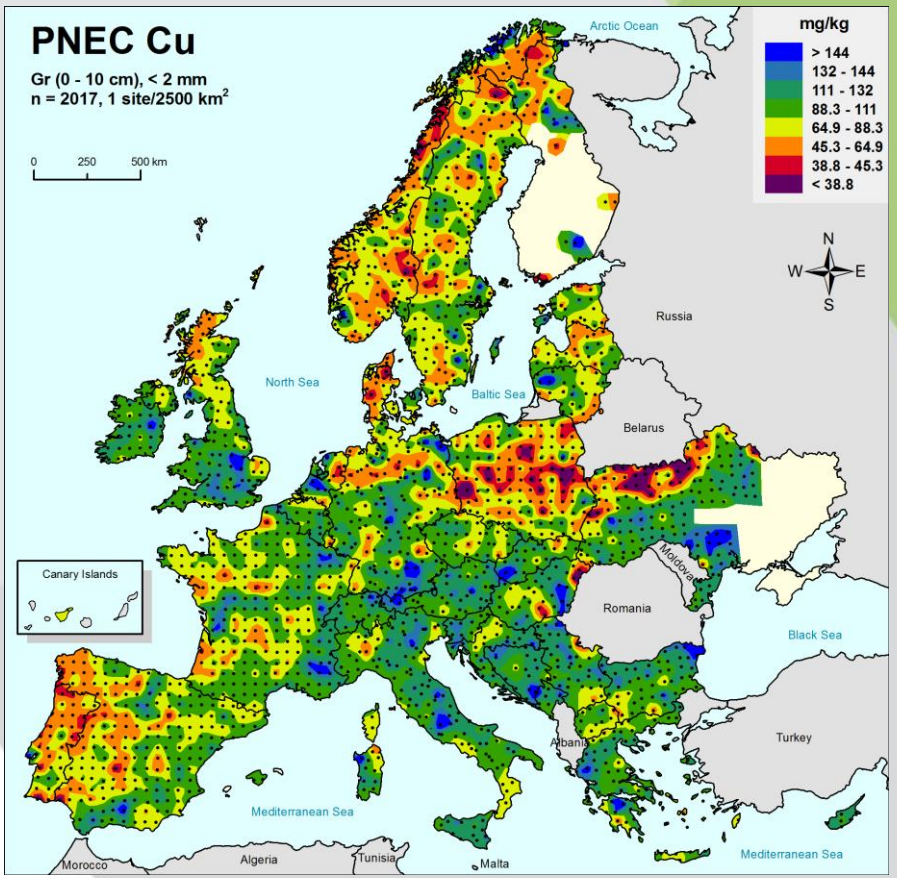
- Natural processes (geology) drive the regional distribution patterns
- No evidence of significant effect of diffuse pollution on the regional distribution

GEMAS: Cu PNEC distribution across Europe

Agricultural soil (A_p) 0-20 cm



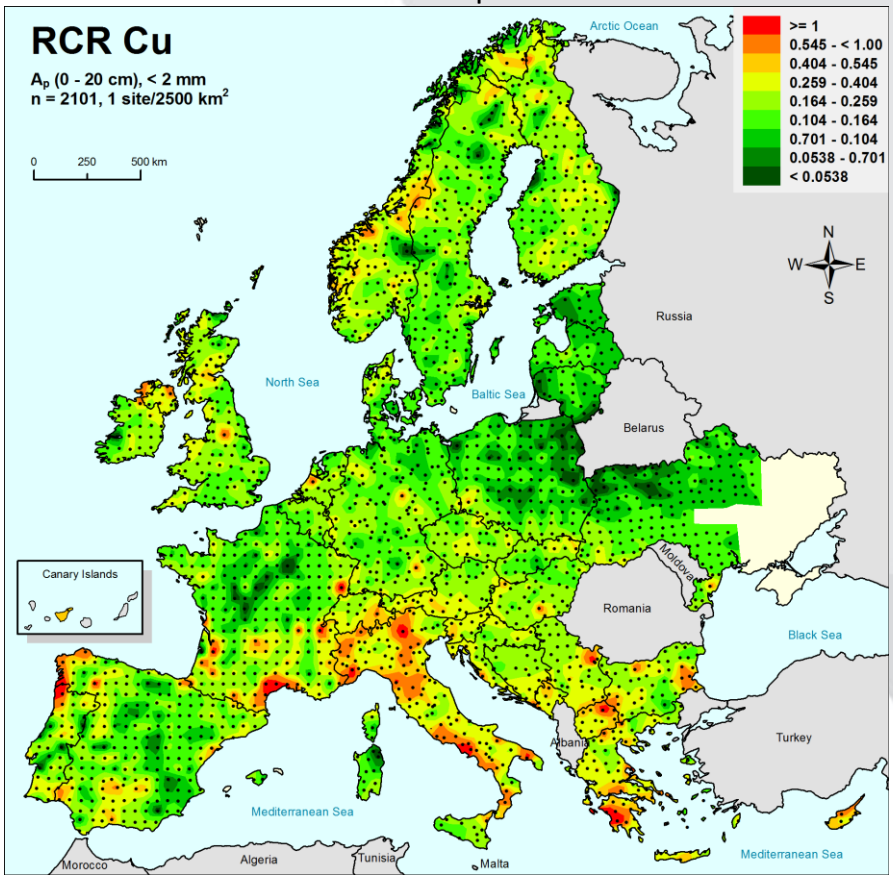
Grazing land soil (Gr) 0-10 cm



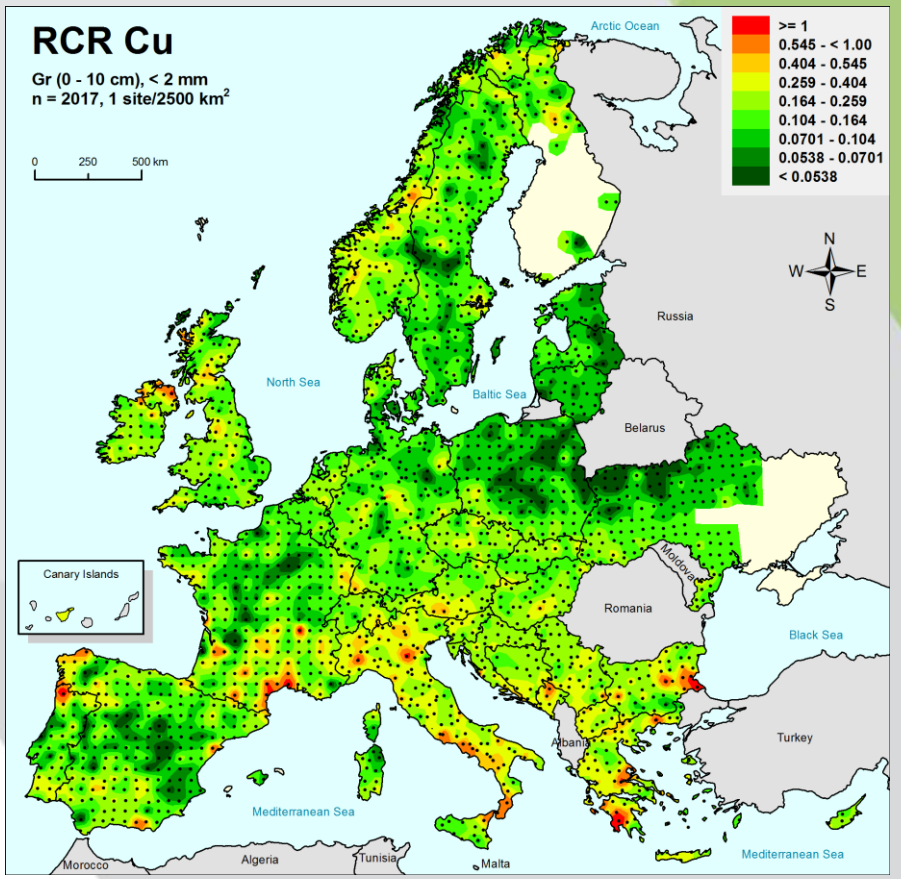
Cu soil PNEC values are highly variable at the regional scale: <20 to >200 mg Cu/kg

GEMAS: Predicted risks of Cu in European soil

Agricultural soil (A_p) 0-20 cm



Grazing land soil (Gr) 0-10 cm



Only few, isolated sites predicted at risk (i.e. RCR > 1): 1.6% and 1.3% of sites for Agricultural and Grazing land, respectively.

Toxicity data for terrestrial organisms and bioavailability corrections for metals

Metal	Reliable toxicity data (+ species covered)	Data normalized with	Lab-Field factor (L/F factor)	Assessment factor on HC_5
Cu^{2+}	252 (28)	eCEC, %clay, %OC, pH	2	1
Zn^{2+}	214 (43)	eCEC, background Zn, pH	3	1
Ni^{2+}	173 (43)	eCEC	1-3 (increasing as a function of pH)	2
Co^{2+}	141 (14)	eCEC	1.1-3.5 (increasing as a function of pH)	2
Pb^{2+}	105 (27)	eCEC	4	1
MoO_4^{2-}	86 (11)	pH, clay	2	1
Cd^{2+}	75 (25)	/	/	2
Ag^{+}	86 (14)	pH, eCEC	2	3
VO_3^{-}	35 (13)	/	1.5	3

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PNECsoil calculator

- Calculates site-specific PNEC based on routinely measured soil properties (pH, % organic carbon, % clay, effective CEC) or for a standard set of different soil types
- Version 4 released in February 2015, available at http://www.arche-consulting.be/en/our-tools/soil-pnec-calculator/
- Metals covered: Cu, Ni, Zn, Pb, Cd, Mo and Co

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PNEC and Risk Characterisation Ratio (RCR) for:

Copper

Back To Input

Results for site specific information:
eCEC= 12.04 cmolc/kg, pH= 7, Org. C= 2 %, Clay= 10 %

	PNEC (mg/kg)	PEC (mg/kg)	RCR /	PAF %
ADDED approach				
PNECadded,site specific	52.8	75	1.42	11.5
TOTAL approach				
PNECtotal,site specific	71.1	100	1.41	12.0

PNEC: Predicted No Effect Concentration of the metal, concentration below which exposure to the metal is not expected to cause an adverse effect
PEC: Predicted (or in this case usually measured) Environmental Concentration of the metal of interest in the soil
RCR: Risk Characterisation Ratio – the PEC divided by the PNEC
PAF: Potentially Affected Fraction, the fraction of terrestrial species predicted to be affected at the metal concentration (PEC) entered

Conclusions

- Extensive databases on effects and regional exposure of metals in soil have been established.
- Variety of simple models and tools are available to take bioavailability into account, based on standard soil properties (pH, organic carbon content, clay content and eCEC).
- Bioavailability correction removes prediction of risk at natural background concentrations, while still ensuring adequate protection.
- Improved scientific method is used for REACH and Biocides regulations and can be used for other regulatory purposes.

Knowledge metal toxicity in soils

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european COPPER institute

NiPERA

Thank you

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