Risk Assessment of Soils containing Non-Extractable Residues (NER)

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Introduction

The focus of this study is to evaluate the formation of non-extractable residues (NER) in soil after application of ^{14}C- test compounds and to assess whether NER are toxic. Residual activity is found to remain in the soil after a 'total' extraction, which can be present as:

- The chemical itself associated with mineral and/or organic matter fractions;
- Transformation product;
- Microbial biomass;
- Carbonates.

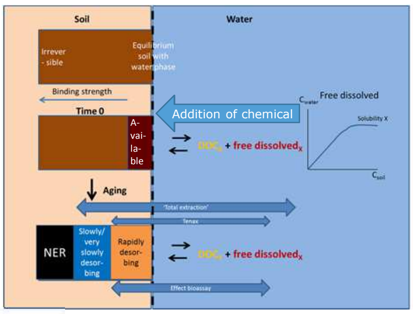
At the moment NER is considered either as a **potential long-term problem** or as a **sustainable detoxification**.

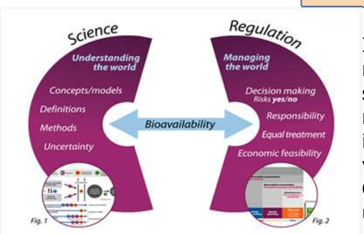
The goal of this study is:

- Develop an "extraction test" to assess the ecotoxicity of fractions representing different degrees of bioavailability of the chemical;
- Provide a clear, mechanistically driven, definition of NER and to confirm a lack of residual toxicity caused by NER.

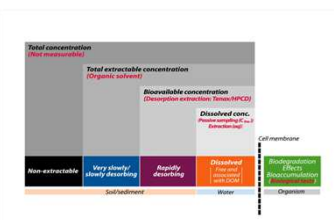
Background

In our approach a contaminant is adsorbed by the soil. At time zero all of the contaminant is bioavailable and may cause risks. All of the contaminant is in equilibrium with the water phase. In time, the contaminant is distributed over different sorption fractions. Biodegradation may be responsible for a decrease of the concentration. Some fractions are measurable, some are not.





In risk assessment, science and regulation meet. To implement scientific approaches into regulation, a simplified approach is necessary based on measurable values, which is proposed by Ortega-Calvo et al. (2015) and used in this study.



In our work, risks have been measured using bio-assays and the results are related to measurable concentrations:

- "Total" extractable concentration using an organic solvent;
- Bioavailable concentration using TENAX® and $CaCl_2$ extraction.

Ortega-Calvo, J.J., J. Harmsen, J.R. Parsons, K.T. Semple, M.D. Aitken, C. Ajao, C. Eadsforth, M. Galay-Burgos, R. Naidu, R. Oliver, W.J.G.M. Peijnenburg, J. Römbke, G. Streck, B. Versonnen, 2015. From Bioavailability Science to Regulation of Organic Chemicals. Environ. Sci. Technol. 2015, 49, 10255−10264

Selection of chemicals and bioassays

- Trinitrotoluene (TNT), Cypermethrin and Carbendazim;
- Sensitive and short tests.


Avoidance test with adult *Eisenia andrei*


Soil microflora – nitrification: step $NH_4^+ \rightarrow NO_2^-$

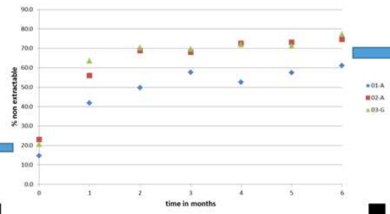

Daphnia magna test.

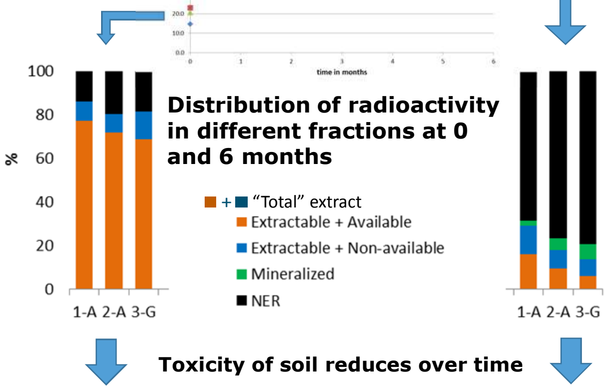

Microtox with *Vibrio fischeri*

Results

Experiments with ^{14}C-TNT show a rapid formation of NER in three different soils (1-A, 2-A and 3-G).

TNT: NER in soil after ASE-extraction





Toxicity of soil reduces over time

Time 0

Soil	Earthworm Avoidance (% effect)	Microtox (% effect)
1-A	100	93
2-A	100	79
3-G	100	79

Time 6 months

Soil	Earthworm Avoidance (% effect)	Microtox (% effect)
1-A	0	22
2-A	0	2
3-G	6	3

The way to go

- Fate study with ^{14}C-Cypermethrin almost finished. NER formation 10-30% in 6 months;
- Fate study with ^{14}C-Carbendazim to be started shortly;
- Focus on measurable fractions and link ecotoxicity with these measurable fractions (Ortega-Calvo et al., 2015);
- Measure residual ecotoxicity after removal of the bioavailable fraction using 0.01M $CaCl_2$ and Tenax®;
- Compare ecotoxicity of aged soil with freshly spiked soil to assess effect of NER formation on ecotoxicity.

Acknowledgment

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