

“Capacity Building and Strengthening Institutional Arrangement”

Workshop: “Hazardous Substances and Wastes”

## Ecological Risk Assessment (ERA)

Ms. Francesca Quercia

APAT

Agency for Environmental Protection and Technical Services

## Index

1. State of art of International ERA
2. ERA elements
3. Site specific risk assessment

# 1. State of the art of international (EU) ERA

## Approaches

- ERA for soil ecosystems, as decision support system to the management of contaminated sites, is a developing discipline, i.e. not yet thoroughly consolidated for site-specific applications.
- Most common experiences, implemented also in some national legislations, address only screening level assessments.

# 1. State of the art of international (EU) ERA

## Protected receptors in EU Risk assessment systems



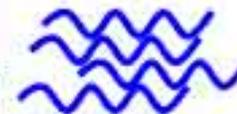
Human health



Terrestrial Ecosystem



Groundwater drinking



Surface Water

	Human health	Terrestrial Ecosystem	Groundwater drinking	Surface Water
Austria	Orange	Green	Light Blue	Dark Blue
Belgium (Flan.)	Orange	Yellow		
Belgium(Wall.)	Orange	Green	Light Blue	
Czech Rep.	Orange	Yellow		
Denmark	Orange		Light Blue	
Germany	Orange	Green	Light Blue	
Finland	Orange	Green		
Italy	Orange		Light Blue	
Lithuania	Orange			
Netherlands	Orange	Green		
Poland	Orange		Light Blue	
Spain	Orange	Green		Dark Blue
Sweden	Orange	Green	Light Blue	Dark Blue
UK	Orange	Yellow		

# 1. State of the art of international (EU) ERA

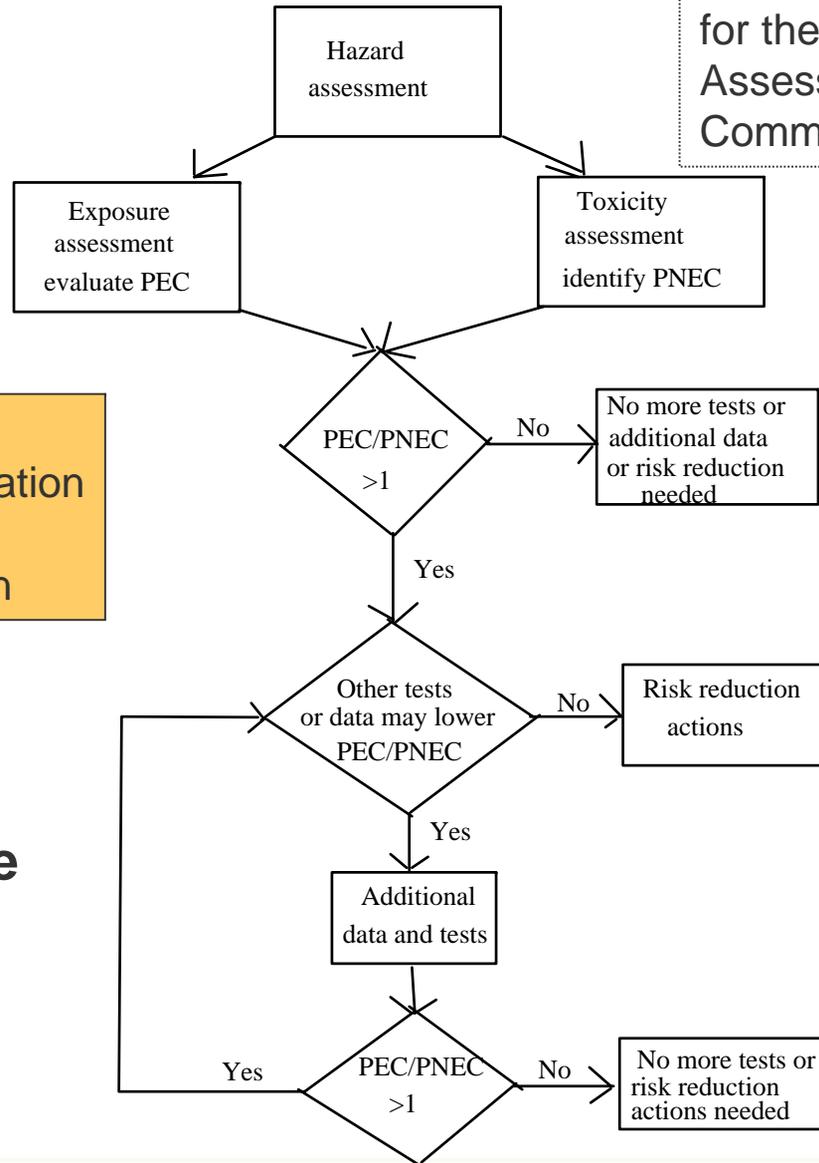
## Protected ecological receptors in EU ERA systems

	Microbiol. Processes	Soil fauna	Plants	Above soil ecosystem	Aquatic ecosystem
<b>Austria</b>					
<b>Belgium – Waloon</b>					
<b>Belgium – Flanders</b>					
<b>Czeck Rep.</b>					
<b>Germany</b>					
<b>Spain</b>					
<b>Finland</b>					
<b>Netherlands</b>					
<b>Sweden</b>					
<b>United Kingdom</b>					

Technical guidelines for ERA have been approved only in Germany, The Netherlands, Finland and Sweden

# 1. State of the art of international (EU) ERA

Technical Guidance Document for the Environmental Risk Assessment of the European Community (EC, 2003)

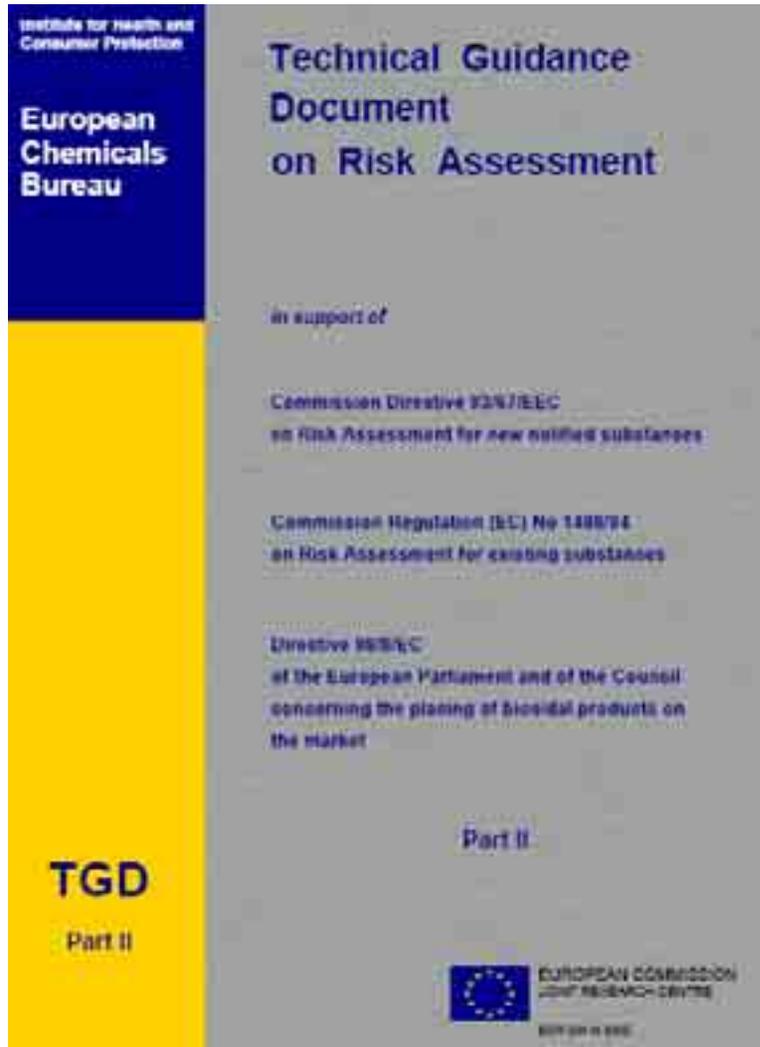


**PEC:** Predicted Environmental Concentration  
**PNEC:** Predicted Non Effect Concentration

## The EC Procedure

# 1. State of the art of international (EU) ERA

## TGD- EC/ECB 2003



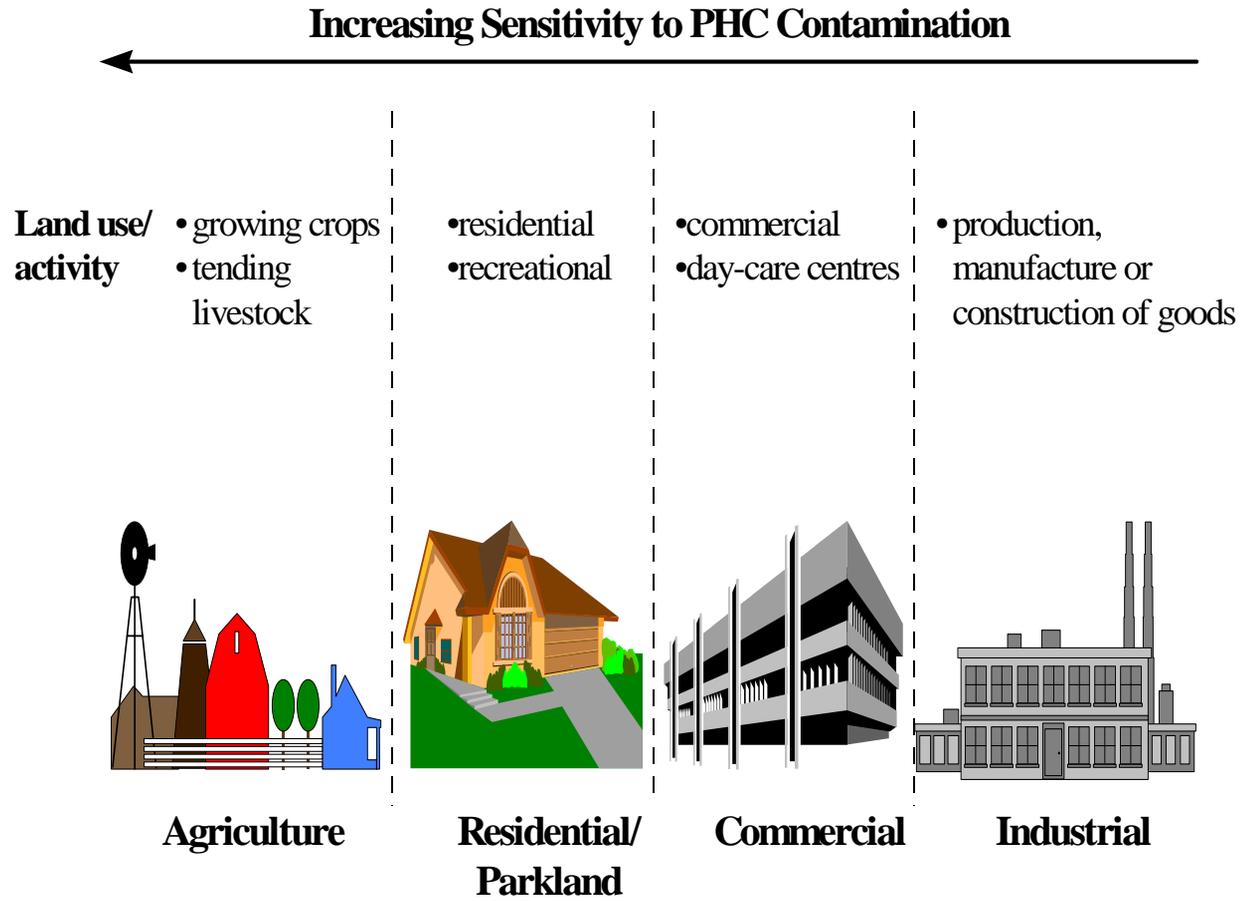
OVERVIEW	
This Technical Guidance Document is presented in four separate, easily manageable parts.	
<b>PART I</b>	
Chapter 1	General Introduction
Chapter 2	Risk Assessment for Human Health
<b>PART II</b>	
Chapter 3	Environmental Risk Assessment
<b>PART III</b>	
Chapter 4	Use of (Quantitative) Structure Activity Relationships ((Q)SARs)
Chapter 5	Use Categories
Chapter 6	Risk Assessment Report Format
<b>PART IV</b>	
Chapter 7	Emission Scenario Documents

## 2. ERA elements

- Soil use destination, soil functions and receptors to be protected
- Chronic/acute exposure effect data (tests are generally available only under acute exposure)
- ‘Assessment endpoints’: mortality, reproduction, growth.....
- Protection level (e.g. % of ecosystem species)
- Bioavailability
- Biomagnification
- Effects of multiple stress sources

## 2. ERA elements

### Soil use destinations



Different soil uses deserve different ecological considerations and requirements. Soil functions and soil ecological processes need to be investigated as well as the trophic structure of organism supporting these functions and processes.

## 2. ERA elements

### Exposure and effect assessment available tools

- Ecotoxicological tests data: chronic NOEC/LOEC or acute LEC data from experiments (for setting screening values)
- PNEC statistical extrapolations from toxicity data (for setting screening values)
- Biological assays (site-specific)
- Biomonitoring (site-specific)
- Biomarkers (site-specific)

## 2. ERA elements

### Screening: use of standardized ecotoxicological tests

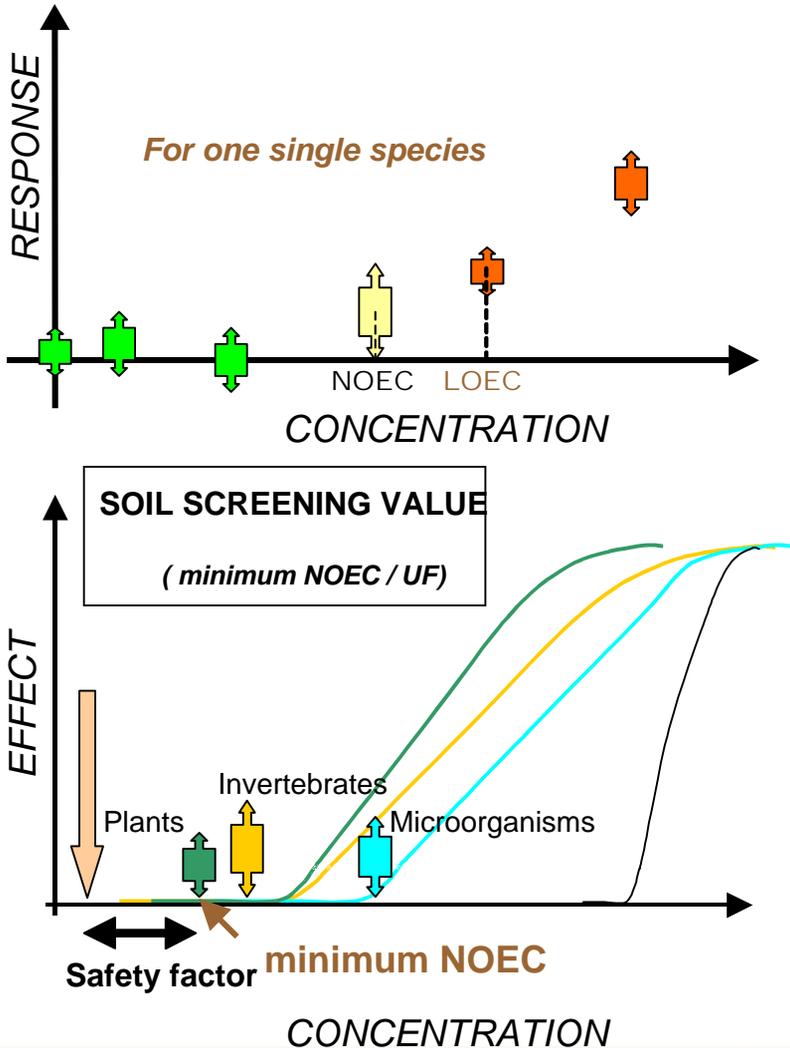
#### Deterministic approach

- Generic screening values are derived by acute or chronic, lethal or non lethal (LC50, NOEC,...) ecotoxicological tests. PNEC is obtained by applying a safety factor in order to account for uncertainties.

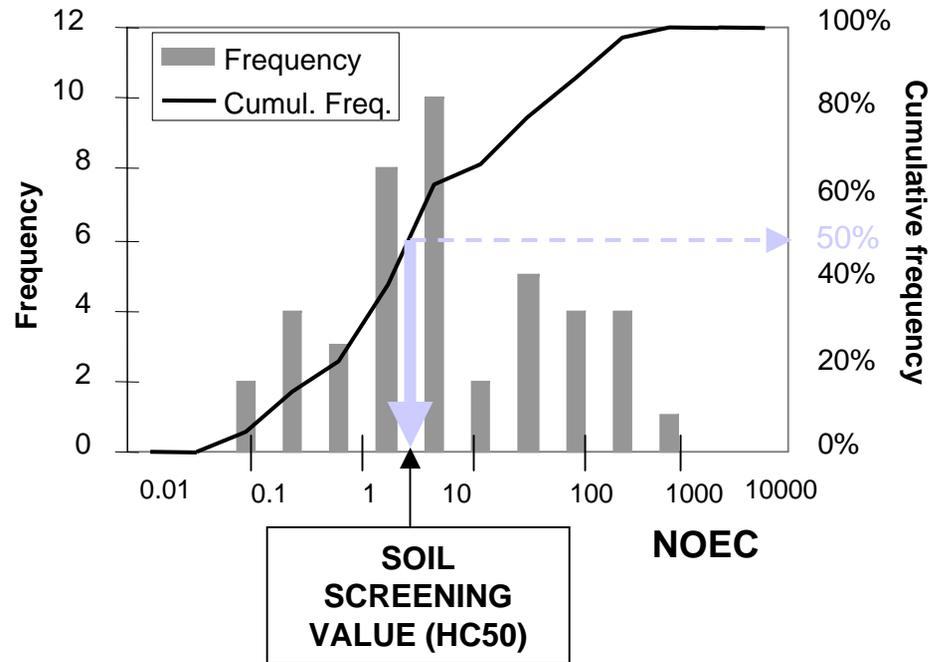
#### Probabilistic approach

- Generic Screening values are derived by NOEC data which are determined by a statistical extrapolation of ecotoxicological tests data (SSDs).

**Deterministic approach =  
Applies Safety Factors**



**PROBABILISTIC APPROACH =  
Defines Species Sensitivity Distributions  
(SSD)**

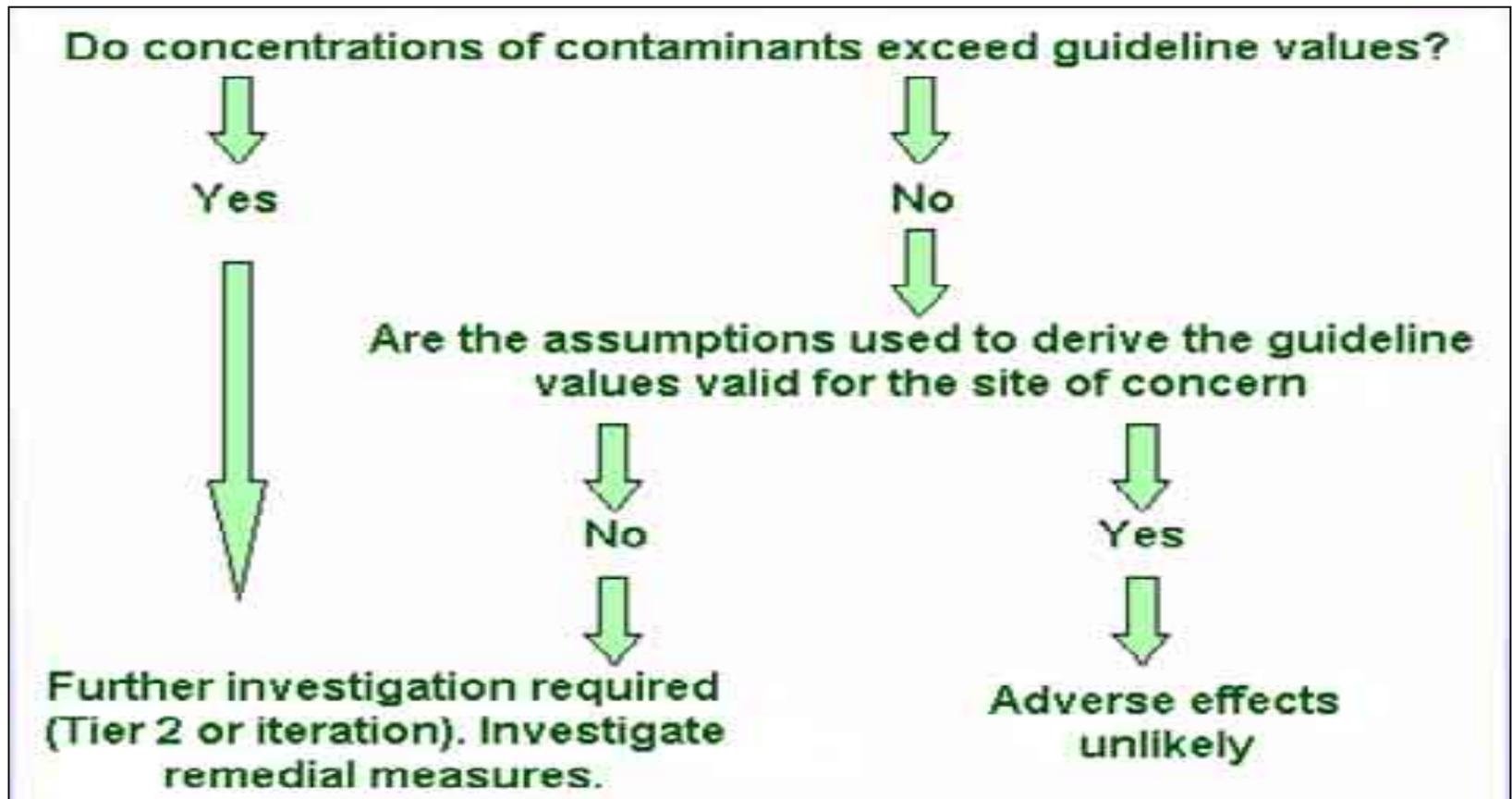


**Defining ERA Based Soil  
Screening Values**

## 2. ERA elements

### Tiered decisional procedure

What contaminant? What pathway? What receptor? What exposure?  
and What effect?



## 2. ERA elements

### Site-specific ERA problem identification

The first part of this step is to assess existing information and identify the problem that the ERA is trying to address.

Any preliminary findings about the site should be documented. Care should be taken to make sure that all available information is carefully assessed before the next stages of the RA are undertaken. At this stage it is important to identify and document the following details:

- current and historic land uses
- potential/actual contaminants of concern
- potential pathways
- potential receptors
- areas of uncertainty.

Preliminary conclusions on the following key factors:

- contaminants of concern;
- potential receptors; and
- main pathways (contaminants release, transport and fate mechanisms).

## 2. ERA elements

### Ecological Risk Assessment Receptor Characterisation

- What ecosystems (receptors) might be affected by contamination and in what way?
- A receptor is any organism that is potentially affected by a contaminant. There are a variety of considerations with regard to receptors, some of which are considered below:
  - scale
  - sensitivity
  - visibility.

## 2. ERA elements

### Receptor Characterisation

#### Scale

Receptors may be identified at a variety of scales ranging from individuals, species, populations and communities, to functional groups, habitats, and ecosystems.

#### Sensitivity

Sensitivity refers to how readily an ecological entity is affected by a particular stressor (USEPA 1998). Sensitivity is influenced by the following factors:

- the mode of action or effect translation of the contaminant;
- individual and community life history characteristics;
- the life stage of an organism at exposure;
- conditions that may change the effect of contaminants.

#### Visibility

The effect of a contaminant may not be immediately visible. The stage of life history and reproductive status may mean that the adverse effect induced by exposure to a contaminant may not be visible until some other time or in some other place.

## 2. ERA elements

### Exposure assessment

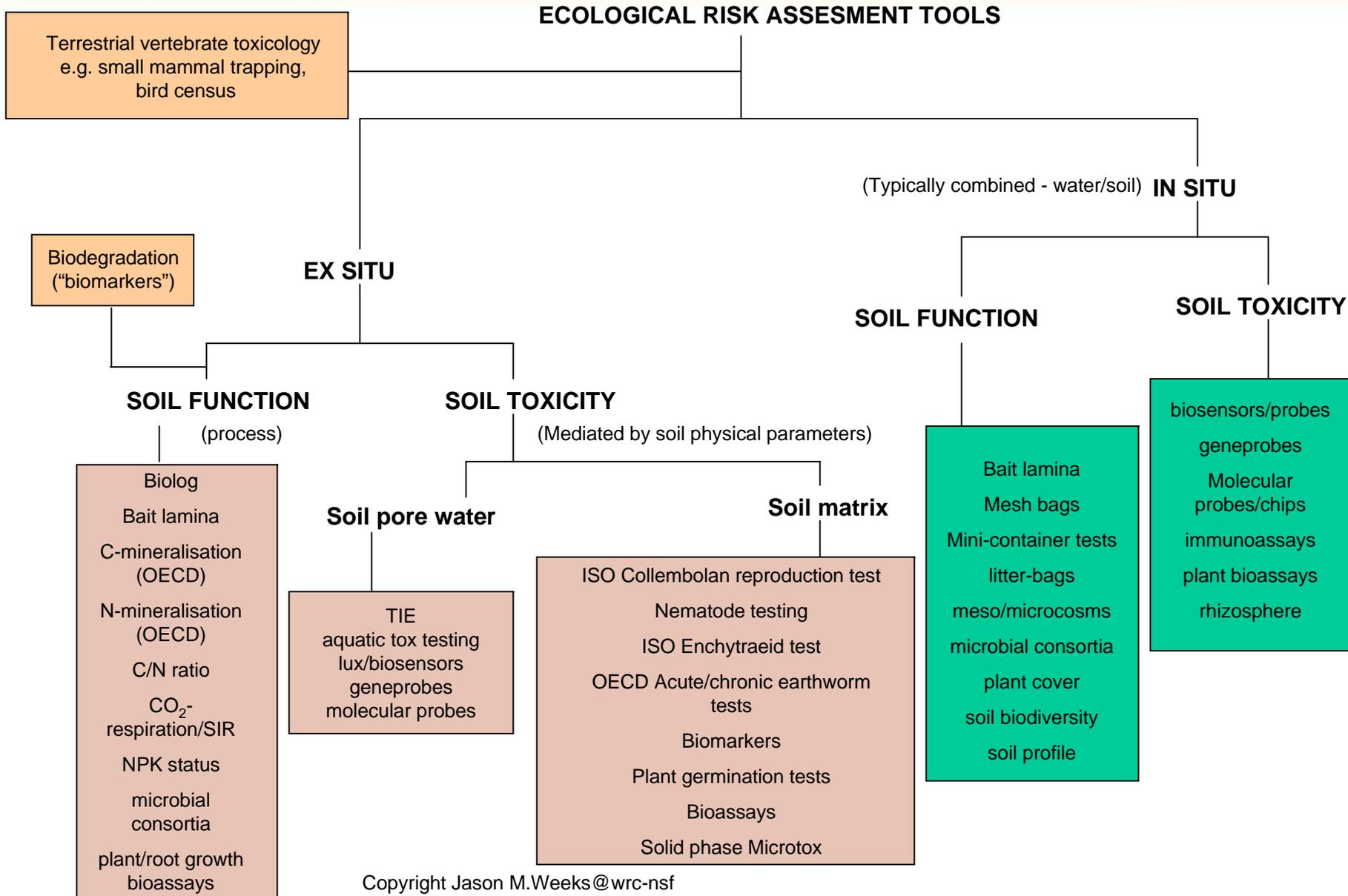
What concentration of contaminants might biosystems be exposed to?

There are several aspects:

- source characteristics (media, contaminant concentration)
- current distribution (location, depth, media)
- transport pathways (physical, +/-biological)
- fate
- estimated receptor exposure/dose.

*Note: Exposure pathway*

*Route by which contaminants enter an organism,  
e.g., via water and/or food.*



## 2. ERA elements

### Example: The Netherlands

- Generic risk assessment (potential risks) for the development of:
  - *Intervention Values*
  - *Target Values*
- Site specific risk assessment (actual risks) for deciding about *urgency of remediation and priorities*

## 2. ERA elements

### Intervention Values (Screening values)

- Indicate a serious contamination
- Human health risk protection criteria:
  - TDI and  $1E-4$ /lifetime excess cancer risk
  - residential with vegetable garden exposure scenario (multifunctional)
  - soil ingestion, inhalation, crop consumption
- Ecological risk protection criteria:
  - HC50 (protection of 50% species) derived by NOEC (*No Observed Effect Concentration*), LOEC (*Lowest Observed EC*) or LEC (*Lethal EC*) data
  - adjustment to soil clay content and organic matter

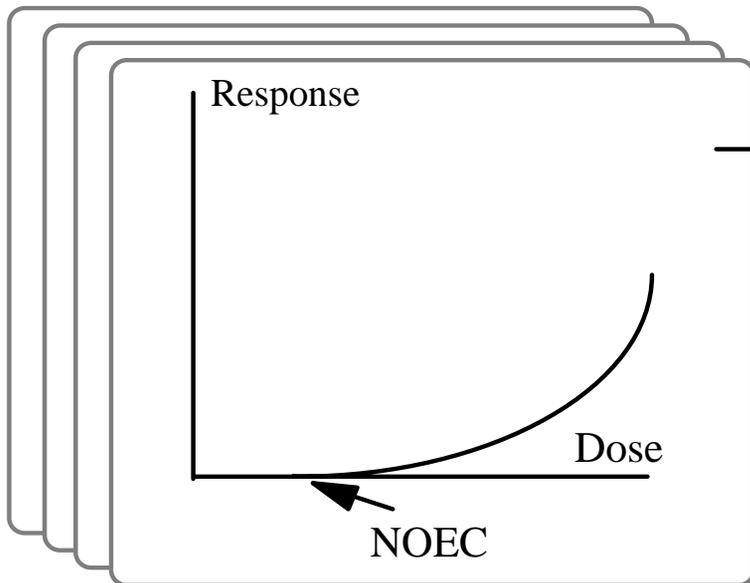
## 2. ERA elements

### Target Values

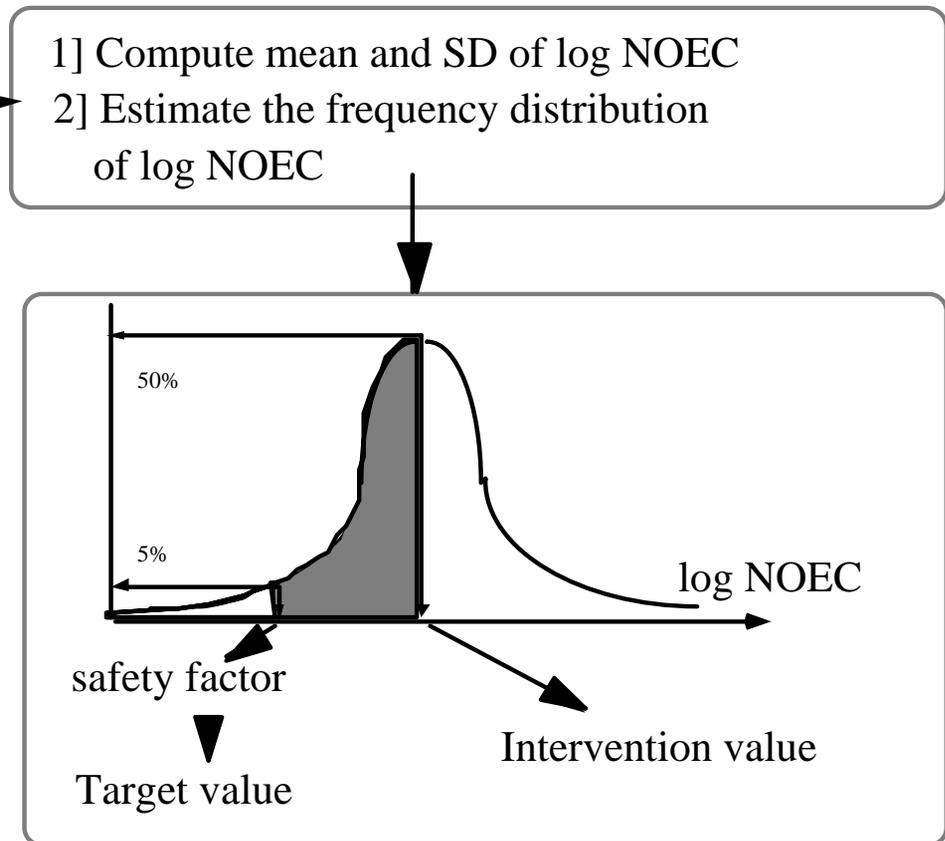
- Indicate a clean soil
- Ecological risk protection criteria:
  - ↑ negligible risk level: HC5 (protects 95% of species)
  - ↑ negligible risk level soil concentration is added to background value for metals

## 2. ERA elements

### Ecotoxicological risk-based criteria



No Observed Effect Concentrations for different species are used to estimate a frequency distribution of NOEC's on a logarithmic scale. Percentiles (5% and 50%) are used to derive Target and Intervention values.



## 3. Site-specific Risk Assessment

- **For remediation urgency:**
- Assess site-specific risk according to local site exposure scenario
- Assess ecological risks by pragmatic procedure based on:
  - ↑ *area sensitivity*
  - ↑ *HC50*
  - ↑ *site area for biodiversity preservation*
  - ↑ *bioassays*

### 3. Site-specific Risk Assessment

**Ecological criteria for the assessment of remediation urgency (pragmatic approach)**

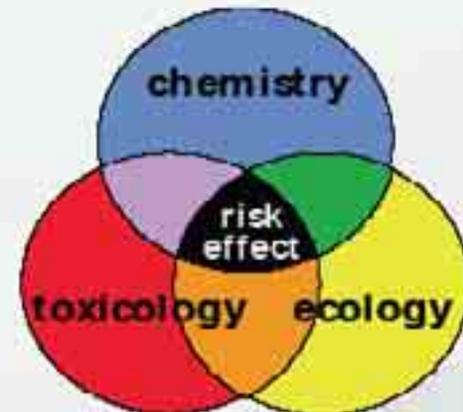
<b>Ecological sensitivity</b>	<b>Concentration in soil &lt; 10xHC50</b>	<b>Concentration in soil &gt; 10xHC50</b>
HIGH: ex. natural reserves, protected areas	50 m <sup>2</sup>	50 m <sup>2</sup>
MODERATE: grazing, residential areas with gardens, recreational areas	5000 m <sup>2</sup>	50 m <sup>2</sup>
LOW: urban areas without gardens, arable fields, vegetable gardens, industry, infrastructures	0.5 km <sup>2</sup>	5000 m <sup>2</sup>

## The TRIAD approach (RIVM, 2001)

### TRIAD hypothesis

Combined effort and evaluation of results from three independent disciplines in ecotoxicology provides pragmatic reduction of conceptual uncertainties

(RIVM, 2001)



Environmental quality criteria exceeded	Toxicity present (bioassays)	Ecological effects in the field	CONCLUSIONS
+	+	+	Strong indication for ecological effects of contamination
-	-	-	No effects
+	-	-	Contaminants present, but not bioavailable
-	+	-	Unknown contamination, toxicity demonstrated
<i>etc.</i>			



## 3. Site-specific Risk Assessment

### Ecotoxicological databases

- National databases (The Netherlands, Spain, Germany, Check Republic, Belgium/Flanders)
- ECOTOX (US.EPA)
- Risk Assessment Reports (RARs) European Chemical Bureau della CE
- Other US databases (IRIS, RAIS, HSDB, ecc.)
- Canadian Council of Ministers of the Environment (CCME) data.

## 3. Site-specific Risk Assessment

### Ecological Risk Assessment needs

- An analytical framework is needed
- Limited experience with terrestrial ecosystems is available
- Ecosystem health needs to be defined
- Fit for use and land use based soil ecological objectives are sought
- Site specific ERA approaches are needed