Environmental risk assessment in the EU – fate and ecotox (incl. dossier requirements)

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Outline of the presentation

• Protection goals for the environment in the EU
• Underlying documents for the environment in the EU
• Dossier requirements in the EU
• Risk assessment (including safety factors)
Protection goals in the EU

- Environmental compartments
  - Soil
  - Groundwater
  - Surface water
  - Air

- Organisms
  - Birds and other terrestrial vertebrates
  - Aquatic organisms
  - Honeybees and other non-target arthropods
  - Earthworms and other soil macro-organisms
  - Soil microbial processes
  - Non-target terrestrial plants
  - Others: sewage treatment micro-organisms
Underlying documents for the environment

Directive 91/414/EEC
- Annex II: Fate and Ecotoxicological studies on the active ingredient (a.i.)
- Annex III: Ecotoxicological studies on the plant protection product
- Annex VI: Uniform Principles (criteria for risk assessment)
Guidance for risk assessment (2)

**Additional guidance:**
- Guidance Document on Aquatic Ecotoxicology
- Guidance Document on Terrestrial Ecotoxicology
- Guidance Document on risk assessment for birds and mammals
- Guidance Document on Persistence in soil
- FOCUS. Soil persistence models and EU registration
- FOCUS groundwater scenarios in the EU Plant protection product review process
- Guidance document on the assessment of the relevant metabolites in groundwater
- FOCUS. Kinetic Analyses of degradation and transformation of the active substances and their metabolites in soil and water in EU registration.
- FOCUS surface water scenarios in the EU evaluation process under 91/414/EEC
- Guidance Document for environmental risk assessments of active substances used on rice in the EU for Annex I inclusion.

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Basic principle of risk assessment in EU

TER = Toxicity Exposure Ratio

\[
TER = \frac{\text{toxicity value (LD}_{50}, \text{LC}_{50}, \text{NEC})}{\text{predicted environmental concentration (PEC)}}
\]

*TER value compared to a criteria*

Registration criteria comprise a Safety factor
- Variation between individuals
- Variation between species
- Lab to field extrapolation
- Acute to long-term effects
Environmental compartments to be protected in the EU

- **Environmental compartments**
  - Soil
  - Groundwater
  - Surface water
  - Air

- **Organisms**
  - Birds and other terrestrial vertebrates
  - Aquatic organisms
  - Honeybees and other non-target arthropods
  - Earthworms and other soil macro-organisms
  - Soil microbial processes
  - Non-target terrestrial plants
  - Others: sewage treatment micro-organisms
Environmental fate studies in EU

Environmental compartments

- Groundwater
  - Transformation rates
    - aerobic / anaerobic
    - Sorption / desorption

- Surface water
  - Transformation rates
    - aerobic / anaerobic
    - Hydrolysis
    - Photolysis
    - Biodegradability
    - Water-sediment studies
    - Sorption / desorption

- Terrestrial environment
  - Transformation routes
    - aerobic / anaerobic
    - Photolysis
    - Biodegradability
    - Water-sediment studies
  - Transformation rates
    - aerobic / anaerobic

- Soil
  - Transformation routes
    - aerobic / anaerobic
    - Hydrolysis
    - Photolysis
    - Biodegradability
    - Water-sediment studies
  - Transformation rates
    - aerobic / anaerobic
Environmental fate studies

Route of degradation in soil

- Aerobic degradation (metabolites, bound residues; OECD-307)
- Anaerobic degradation (metabolites, bound residues; OECD-307)
- Soil photolysis (metabolites, bound residues; OECD draft guideline)

Rate of degradation in soil

- Aerobic degradation of active substances and relevant metabolites (DT50 and DT90 values; OECD-307)
- Anaerobic degradation of active substances and relevant metabolites (DT50 and DT90 values; OECD-307)
Environmental fate studies

Field studies in soil
- Soil dissipation studies (metabolites; DT50 and DT90-values; SETAC guidelines)
- Soil accumulation studies (DT50 and DT90-values; SETAC guidelines)
Environmental fate studies

Mobility studies in the soil

- Adsorption and desorption of the active substance and relevant metabolites (Kom-values; OECD-106)
- Column leaching studies with the active substance and relevant metabolites (Kom-values; OECD-106)
- Aged residue column leaching (Kom-values; OECD-106)
- Lysimeter studies (OECD Series on Testing and Assessment No. 22)
- Field leaching studies (SETAC-guideline)
Environmental fate studies

Fate and behaviour in water

- Hydrolytic degradation (hydrolytic breakdown products, DT50-values; OECD-111)
- Photochemical degradation (breakdown products, DT50-values; OECD-309)
- Test on “Ready biodegradability” (EEC Method 4)
- Water/sediment study (metabolites formed in water and sediment, DT50 and DT90 values; OECD-308)

Fate and behaviour in air

- Route and rate of degradation in air (guidance under development)
Environmental fate: criteria for protection goals

- Groundwater: concentration < 0.1 ug/L
- Surface water used for drinking water: concentration < 0.1 ug/L
- Soil: No DT90 > 1 year or DT50 > 3 months, unless there is no accumulation in the soil at such levels that there is an unacceptable impact on succeeding crops and the environment or unacceptable phytotoxic effects
- Air: No PEC from airborne transport in the respective environmental compartments resulting in unacceptable impact on the environment
- POP, PBT and vPvB criteria introduced in the revised Annex VI
Questions???????
Ecotoxicological protection goals

- Environmental compartments
  - Soil
  - Groundwater
  - Surface water
  - Air

- Organisms
  - Birds and other terrestrial vertebrates
  - Aquatic organisms
  - Honeybees and other non-target arthropods
  - Earthworms and other soil macro-organisms
  - Soil microbial processes
  - Non-target terrestrial plants
  - Others: sewage treatment micro-organisms
Information per organism to be protected

Dossier requirements per protection goal
- First tier
- Higher tiers

Risk assessment
- First tier
- Higher tiers
Birds and other terrestrial vertebrates

- Birds
- Mammals
Birds: dossier requirements

First tier tests
- Acute oral toxicity
- Sub-chronic toxicity and reproduction

Higher tier tests
- Avoidance/palatability tests
- Pen/cage studies
- Field tests

No agreed standard protocols for higher tier tests!
Acute oral toxicity
- required when exposure is possible
- one species (quail species or mallard duck)
- guideline: OECD 401
- Endpoint: LD$_{50}$; NOEL
Birds: dossier requirements (3)

Sub-chronic toxicity and reproduction
- required when exposure is possible during the breeding season
- one species (quail species or mallard duck)
- guideline: OECD 206
- endpoint: NOEC (reproduction)

Effects on secondary poisoning
- in the case of rodenticides
- secondary poisoning of predators and scavengers
Birds: Risk assessment

First tier:
Acute: $\text{TER} = \frac{\text{oral LD}_{50}}{\text{PEC}}$ \hspace{1cm} $\text{TER} > 10$
Sub-chronic or reproduction: $\text{TER} = \frac{\text{NOEC}}{\text{PEC}}$ \hspace{1cm} $\text{TER} > 5$

Higher tier:
Depending on specific problems, case by case decision
Mammals: dossier requirements

Studies from the human toxicological data package

**Acute oral toxicity study** (rat)
- endpoint: LD$_{50}$ (acute)

**Multigeneration study or teratogenicity study**
- endpoint: NOEC (long term)
Mammals: Risk assessment

First tier:
Acute: $\text{TER} = \frac{\text{oral LD}_{50}}{\text{PEC}}$  \hspace{1cm} \text{TER} > 10
Sub-chronic or reproduction: $\text{TER} = \frac{\text{NOEC}}{\text{PEC}}$  \hspace{1cm} \text{TER} > 5

Higher tier:
Depending on specific problems, case by case decision
Questions??????
Aquatic organisms

- Fish (including BCF)
- Aquatic invertebrates
- Algae
- Sediment dwelling organisms
- Aquatic plants
Fish: dossier requirements

First tier tests
- Acute toxicity to fish
- Chronic toxicity to fish
- Bioconcentration (BCF) in fish

Higher tier tests
- Single species tests in water/sediment systems
- Semi-realistic microcosm study
- Mesocosm study
Fish: dossier requirements (2)

**Acute toxicity to fish**
- always required
- 2 species:
  - rainbow trout (*Oncorhynchus mykiss*)
  - warm water fish species (e.g. bluegill sunfish)
- guideline: OECD 201
- Endpoint: 96 h LC$_{50}$

**Chronic toxicity to fish**
Always required unless:
- >90% loss by hydrolysis over 24 h

3 types of chronic tests:
- chronic toxicity test on juvenile fish
- fish early life stage toxicity test
- fish full life cycle test
Chronic toxicity tests to fish

Chronic toxicity test on juvenile fish (rainbow trout)
- test period: 28 days
- guideline: OECD 215
- endpoint: NOEC (survival, growth, behavior)

Fish early life stage toxicity test
required when:
- 100 < BCF < 1000 and acute LC\textsubscript{50} (a.i.) < 0.1 mg/L
- guideline: OECD 210
- endpoint: NOEC (development, growth, behavior)

Fish full life cycle test
Required when:
- BCF > 1000 and elimination during the 14 day depuration phase < 95% (bio-concentration study) and a.i. stable in water or sediment (DT90 > 100 days) and acute LC\textsubscript{50} < 0.1 mg/L
- Endpoint: NOEC (reproduction, viability of filial generation)
Bioconcentration factor (BCF) in fish
Required when log Pow > 3
• Not necessary when:
  - exposure not likely to occur
  - DT90 (whole system) < 10 days, unless multiple applications
Fish: Risk assessment

First tier:
Acute: \( \text{TER} = \text{LC}_{50} / \text{PEC} \): \( \text{TER} > 100 \)

Chronic: \( \text{TER} = \text{NOEC} / \text{PEC} \) \( \text{TER} > 10 \)

Higher tier:
Depending on specific problems (e.g. micro- or mesocosms), criteria to be used case by case
Fish, BCF: Risk assessment

First tier:
For a.i. which are readily biodegradable  BCF < 1000
For a.i. which are not readily biodegradable  BCF < 100

Higher tier:
- No direct or indirect effects for aquatic organisms
- Secondary poisoning birds and mammals
Aquatic invertebrates: dossier requirements

First tier tests
- Acute toxicity to aquatic invertebrate
- Chronic toxicity to aquatic invertebrates

Higher tier tests
- Single species tests in water/sediment systems
- Semi-realistic microcosm study
- Mesocosm study
Aquatic invertebrates: dossier requirements (2)

Acute toxicity to aquatic invertebrates
- Always required
- Test species: *Daphnia magna*
- Guideline: OECD 202
- Endpoint: 48 h EC$_{50}$ (immobilization)

Chronic toxicity to aquatic invertebrates
- Always required, unless:
  >90% loss by hydrolysis over 24 h
- Guideline: OECD 211
- Endpoint: 21 d NOEC (immobilization, reproduction)
Aquatic invertebrates: dossier requirements (3)

Insecticides

For insecticides *Daphnia magna* is not always the representative species:
- when toxicity of insecticide is low for *Daphnia* (48 h EC\textsubscript{50} > 1 mg/L; 21 d NOEC > 0.1 mg/L), then acute test with *Chironomus riparius* (first instar; water only study)
- if 48 h EC\textsubscript{50} (*Chironomus*) < 0.1 x 48 h EC\textsubscript{50} (*Daphnia*), a chronic study with *Chironomus riparius* is required
Aquatic invertebrates: Risk assessment

First tier:
Acute: $\text{TER} = \frac{\text{LC}_{50}}{\text{PEC}}$

Chronic: $\text{TER} = \frac{\text{NOEC}}{\text{PEC}}$

Higher tier:
Depending on specific problems (e.g. micro- or mesocosms), criteria to be used case by case
Algae: dossier requirements

First tier tests
- Acute toxicity to algae

Higher tier tests
- Single species tests in water/sediment systems
- Semi-realistic microcosm study
- Mesocosm study
Toxicity test on algal growth
- always required
- normally one species (green algae)
- herbicides and plant growth regulators: second algal species is required from different taxonomic group
- guideline: OECD 203
- endpoint: 96 h EC$_{50}$ (biomass, growth rate)
First tier:
Acute: TER = EC$_{50}$ / PEC: TER > 10

Higher tier:
Depending on specific problems (e.g. micro- or mesocosms), criteria to be used case by case
Aquatic plants: dossier requirements

First tier tests
- Acute toxicity to aquatic plants

Higher tier tests
- Single species tests in water/sediment systems
- Semi-realistic microcosm study
- Mesocosm study
Toxicity test on aquatic plants
- required for herbicides and plant growth regulators
- test species: *Lemna* sp.
- guideline: ASTM or EPA
- endpoint: 14 d EC$_{50}$ (number of fronds, biomass)
Aquatic plants: Risk assessment

First tier:
Acute: $\text{TER} = \frac{\text{EC}_{50}}{\text{PEC}}$

Higher tier:
Depending on specific problems (e.g. micro- or mesocosms), criteria to be used case by case

TER > 10
Sediment dwelling organisms: dossier requirements

First tier tests
- Chronic toxicity to sediment dwelling organisms

Higher tier tests
- Semi-realistic microcosm study
- Meso-cosm study
Toxicity test on sediment dwelling organisms

- Normally a chronic test is required
- Trigger:
  - when > 10% of AR (a.i.) in the sediment at or after day 14 and
  - chronic NOEC (*Daphnia*) < 0.1 mg/L
- Test species: *Chironomus riparius*
  - spiked water toxicity test (OECD 219)
  - spiked sediment toxicity test (OECD 218)
- Endpoint: 28 d NOEC (survival and development)
Sediment dwelling organisms: Risk assessment

First tier:
Chronic: \[ \text{TER} = \frac{\text{NOEC}}{\text{PEC}} \]
\[ \text{TER} > 10 \]

Higher tier:
Depending on specific problems (e.g. micro- or mesocosms), criteria to be used case by case
Questions???????
Honeybees and other non-target arthropods

- Bees
- Non target arthropods
Bees: dossier requirements

First tier
- Acute toxicity to bees
- Bee brood feeding test

Higher tier
- Cage/tent/tunnel or field trial
Acute toxicity to bees

- oral toxicity test
- contact toxicity test

• required when exposure to bees is possible
• guidelines: EPPO 170, OECD 213 and 214
• endpoint: 48 h oral LD$_{50}$; 48 h contact LD$_{50}$
Bees: dossier requirements (3)

**Bee brood feeding test**
- Required when pesticide is an Insect Growth Regulator (IGR)
- Guideline: Oomen et al. (1992)

**Higher tier tests with bees**
- Cage/tent/tunnel or field trials
- Guideline: EPPO 170
Bees: risk assessment

First tier:
Acute: oral or contact $LD_{50}$ (ug/bee) / PEC (dose) (g/ha) \(TER > 0.02\)

Higher tier:
Cage/tent/tunnel/ field trials : no statistical difference in effects between the control and treatments (survival and development)
Non target arthropods: dossier requirements

First tier
- Effect tests on glass plates

Higher tier tests
- Extended laboratory tests, aged-residue tests, (semi-) field studies
Tests are required when exposure is possible

First tier testing: glass plate tests with:
- parasitoid (*Aphidius rhopalosiphi*) → standard species
- predatory mite (*Typhlodromus pyri*) → standard species
- Two extra species (depending on application according to SETAC)
- endpoint: LR50

Higher tier tests
Required when risk is indicated in Tier I tests
- extended laboratory tests
- aged-residue tests
- (semi-) field studies
- Guideline: SETAC
Non-target arthropods: risk assessment

First tier:
Standard species: TER = LR50 / PEC
\( \text{TER} > 0.5 \) (Aphidius rhopalosiphi and Typhlodromus pyri)

Non standard species:

Higher tier:
All species:

Recovery
- in-field: before next season
- off-field: ecological relevant period
Earthworms: dossier requirements

First tier tests
- Acute toxicity to earthworms
- Sub-lethal toxicity to earthworms

Higher tier tests
- Earthworm field studies
Earthworms: dossier requirements (2)

Acute toxicity to earthworms
- required when exposure of soil is possible
- guidelines: OECD 207; ISO 11268-1:1993; 88/302/EC
- endpoint: 14-day LC$_{50}$

Sub-lethal toxicity
- triggers:
  - always when acute TER < 10
  - always when DT$_{90f}$ > 365 days or when no. of applications > 6
- guidelines: ISO 11268-2; forthcoming OECD 222
- endpoint: NOEC (growth, reproduction and behavior)
Earthworm field studies

- Required when TER (long term)< 5
- Guideline: ISO 11268-3: 1999
Earthworms: risk assessment

First tier:
Acute: TER = LC$_{50}$/ PEC  \hspace{1cm} TER > 10

Chronic: TER = NOEC /PEC  \hspace{1cm} TER > 5

Higher tier:
Depending on specific problems, criteria to be used case by case, expert judgment

Recovery: before next season
Other soil non-target macro-organisms

Test on the effects on other soil non-target macro-organisms

• When:
  - risk for arthropods (*Aphidius*/ *Typhlodromus*) in the first tier
  - pesticide directly applied to soil

• Possible tests
  - test on *Collembola* reproduction
  - test on gamasid mites (*Hypoaspis aculeifer*)

• Guidelines:
  - *Collembola*: ISO 11267: 1999
  - *Hypoaspis*: Løkke and Van Gestel (1998); Bakker et al. (2002)
Other soil non-target macro-organisms: risk assessment

First tier:
Chronic: TER = NOEC / PEC

TER < 5

Higher tier:
Depending on specific problems, criteria to be used case by case, expert judgment
Non-target terrestrial plants: dossier requirements

**Tier 1**
- Available information, preferably screening data
- At least 6 species from different taxa tested at the highest nominal application rate

**Tier 2** (if potential risk in Tier 1 is identified)
- Dose-response tests on 6 – 10 plant species representing as many taxonomic groups as possible
- Guideline: OECD 208; EPA
- Endpoint: ER$_{50}$

**Tier 3** (if still risk in Tier 2)
- Field or semi-field studies
- No standardized protocols
Non-target terrestrial plants: risk assessment

**Tier 1:**
For all of the species of the screening test: effect < 50%

**Tier 2:**
TER = ER$_{50}$/dose: TER > 5
or
TER = HR$_{5}$/dose (probabilistic: 6-10 species): TER > 1

**Tier 3:**
Depending on specific problems, criteria to be used case by case
Soil microbial processes: dossier requirements

First tier tests
- Soil nitrification
- Carbon mineralization

Higher tier tests
- Field studies (no protocol, expert judgment)

Soil nitrification and soil carbon mineralization test
- required when exposure of soil is possible
- guidelines: OECD 216/217
- endpoint: Effect %
Soil microbial processes: Risk assessment

First tier:
Effects on Soil nitrification < 25 % after 100 days
Effects on carbon mineralization < 25 % after 100 days

Higher tier:
Field research (soil nitrification or carbon mineralization):
no statistical difference between the control and the treatments

Recovery
- before next season
Other: Sewage treatment plant (STP)

Effects on biological methods for STP
• Required when exposure of Sewage Treatment Plants is possible
• Guideline: OECD 209
• endpoint: L(E)C$_{50}$

Risk assessment:
No standardized criteria in 91/414
There is more to deal with……

- Formulations
- Metabolites
- Etc........
Questions???????
Environmental risk assessment

Options for Ethiopia?
Define protection goals

- Before environmental risk assessment procedures can be developed, national protection goals need to be defined.
  
  - What do we want (need) to protect?
  - Where do we want to protect it?
  - How strict do we want to protect it? What is an unacceptable effect?
Define protection goals

• **What** do we want to protect?

• Which groups of non-target organisms (or environmental compartments) should not be affected by the pesticide at unacceptable levels?

• E.g. for the aquatic environment:
  – all aquatic organisms?
  – only all fish?
  – only all commercially harvested fish?
  [can they be separated?]
General protection goals in Ethiopia?

- What are priority environmental compartments and organisms in Ethiopia?

- Should we develop hazard/risk assessment for all groups, or start with a limited number?
Define protection goals

- **Where** do we want to protect?
- E.g.: EU – Aquatic environment
  - Aquatic organisms in ditches adjacent to agricultural fields
- E.g.: EU – Soil environment
  - Soil organisms and processes in top 5 cm of soil
- E.g.: EU – Bees
  - Honey bees, everywhere

Can we define where for some Ethiopian cases?
Define protection goals

- **How strict** do we want to protect?

- E.g.: EU – Aquatic environment
  - No acute and chronic effects on aquatic organisms allowed

To be defined for Ethiopia
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## Relevance for use in Ethiopia

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