# Soil contamination by pesticide residues

## what and how much should we expect to find in EU agricultural soils based on pesticide representative uses?

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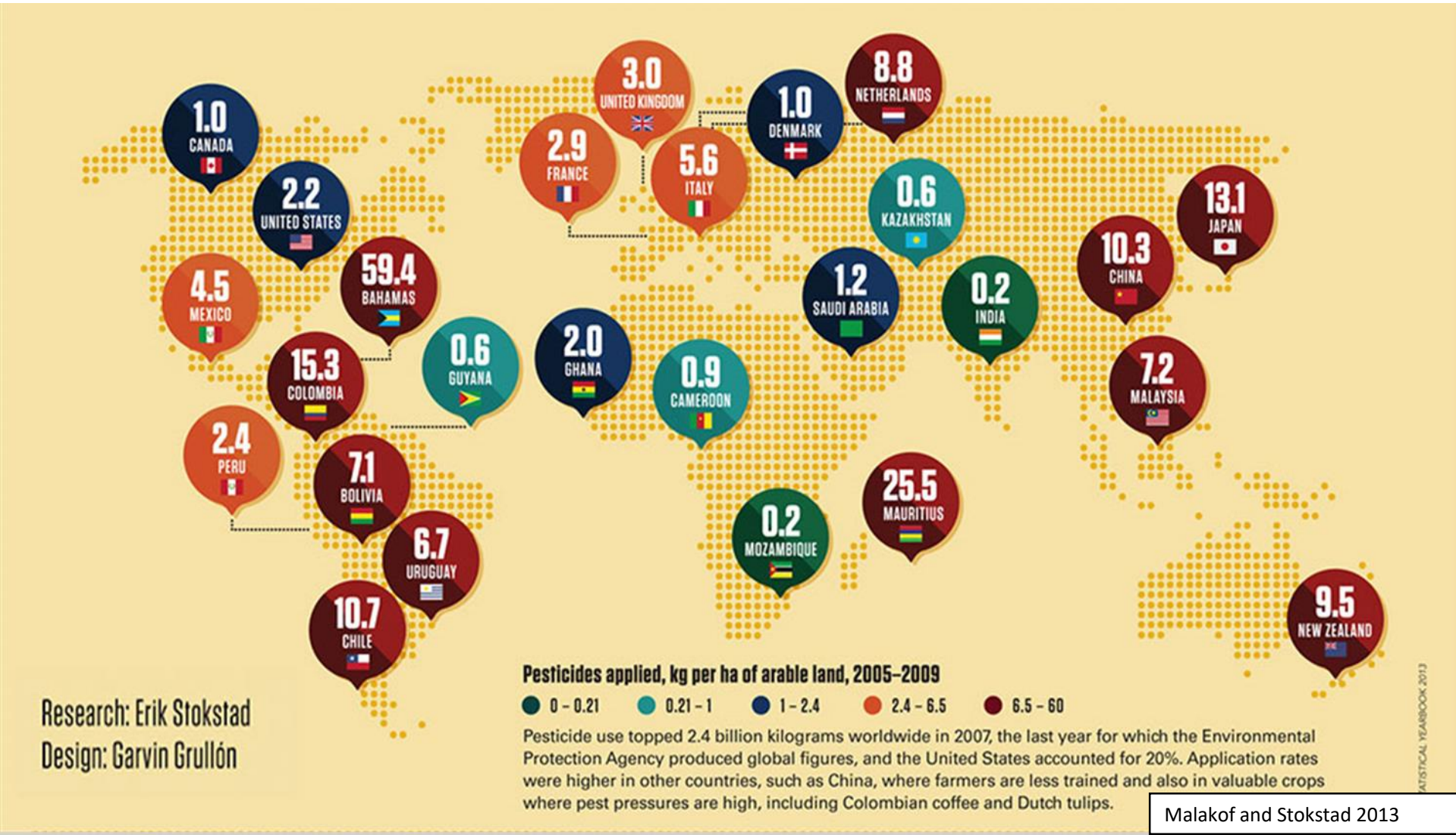
iSQAPER Interactive Soil Quality Assessment

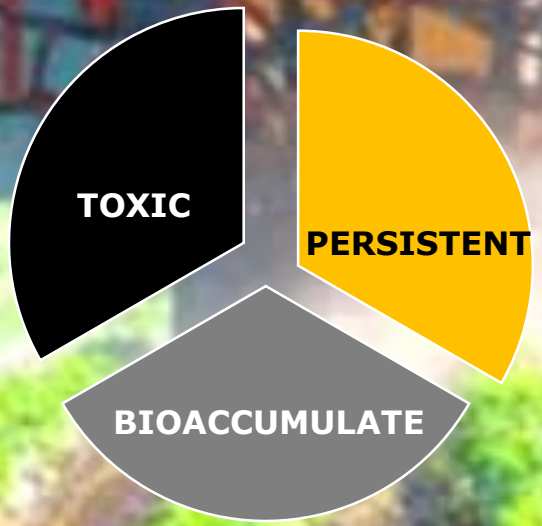
RECARE Preventing and Remediating degradation of soils in Europe through Land Care

# Pesticides:

- heavily used in agriculture to reduce crop losses due to pests, weeds and pathogens
- World use: > 4 million tonnes, > 40 billion USD/year
- EU use: > 0.5 million tonnes - > 2,000 products, 484 active substances (a.s.)




Malakof and Stokstad 2013



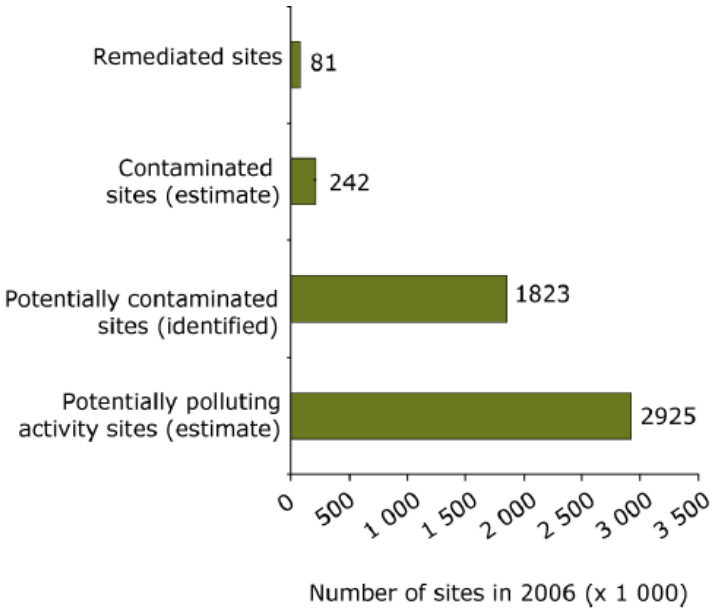

## PARADOX: yield - off-site effects

a substantial amount of applied pesticides does not reach the target

# Contamination status of EU soils?

"It is difficult to quantify the real extent of local soil contamination as **many European countries lack comprehensive inventories** and there is a **lack of EU legislation** obliging Member States to identify contaminated sites"

*Jones et al. 2012*




**Environm. distribution data**
- specific studies
- often only a few a.s. and/or a relatively small area
- differ also on sampling strategy, analytical details,...

**Pesticide use data**
- EUROSTAT and FAOSTAT
- limited or too generalist

**Pesticide Representative uses**
- **EU dossiers (individual a.s.)**
- **Recommended application rates, crops, region...**

# Pesticide Representative uses - methodology

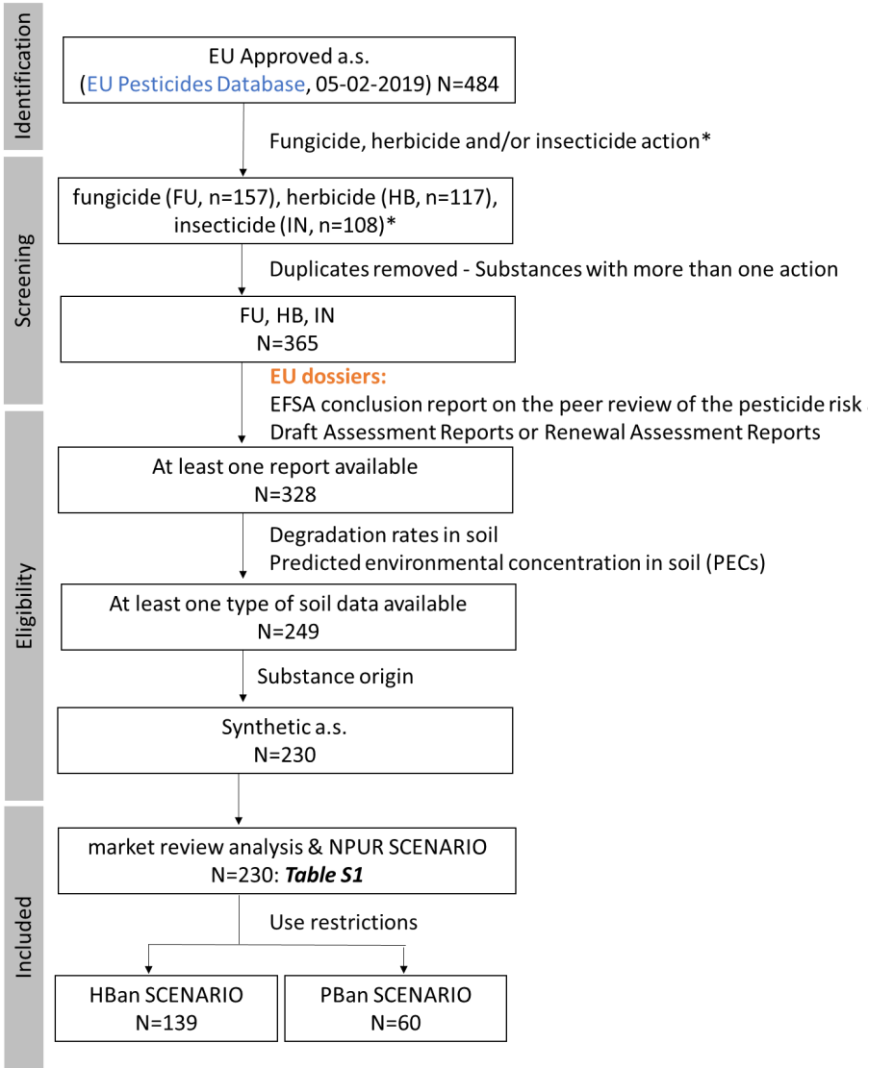
- 230 active substances (a.s.)
- 8 crops

  cereals, maize, root crops,
  non-permanent industrial crops,
  permanent crops, grapes,
  dry pulses-vegetables-flowers, and
  temporary grassland
- 3 EU regions

  NEU, CEU, SEU
- 3 pesticide use scenarios

  NPUR, Hban, Pban
- Quality thresholds

  0.25 and 0.75 max. number of a.s.
  0.25 and 0.75 max. total pesticide content






* NEU=Northern EU, CEU=Central EU, SEU=Southern EU
* NPUR=no pesticide use restrictions, HBan=herbicides banned, PBan=pesticides banned.
* Pban represents recent stop of pesticides, and cover only very persistent a.s. (DT90>365 days)

# Pesticide Representative uses - results

- 230 active substances (a.s.) ➔ ecological risks

| Organism | Number of a.s. | | | |
|---|---|---|---|---|
| | Low toxicity | Moderate toxicity | High toxicity | No data found |
| Mammals – acute | 108 (47%) | 99 (43%) | 15 (7%) | 8 (3%) |
| Mammals – long term | 0 (0%) | 16 (7%) | 116 (50%) | 98 (43%) |
| Birds – acute | 73 (32%) | 134 (58%) | 14 (6%) | 9 (4%) |
| Birds – long term | 83 (36%) | 99 (43%) | 3 (1%) | 45 (20%) |
| Fish – acute | 17 (7%) | 175 (76%) | 34 (15%) | 4 (2%) |
| Fish – long term | 31 (13%) | 136 (59%) | 27 (12%) | 36 (16%) |
| Aquatic invertebrates – acute | 17 (7%) | 165 (72%) | 41 (18%) | 7 (3%) |
| Aquatic invertebrates – long term | 30 (13%) | 128 (56%) | 41 (18%) | 31 (13%) |
| Aquatic plants – acute | 19 (8%) | 94 (41%) | 28 (12%) | 89 (39%) |
| Algae – acute | 47 (20%) | 154 (67%) | 21 (9%) | 8 (3%) |
| Honeybees – acute | 55 (24%) | 142 (62%) | 23 (10%) | 10 (4%) |
| Other terrestrial arthropods* – not available | 49 (21%) | 10 (4%) | 27 (12%) | 144 (63%) |
| Earthworms – acute | 9 (4%) | 207 (90%) | 5 (2%) | 9 (4%) |
| Earthworms – long term | 13 (6%) | 109 (47%) | 2 (1%) | 106 (46%) |
| Other soil macro-organisms* – acute | 0 (0%) | 3 (1%) | 3 (1%) | 224 (97%) |
| Other soil macro-organisms* – long term | 7 (3%) | 14 (6%) | 0 (0%) | 209 (91%) |

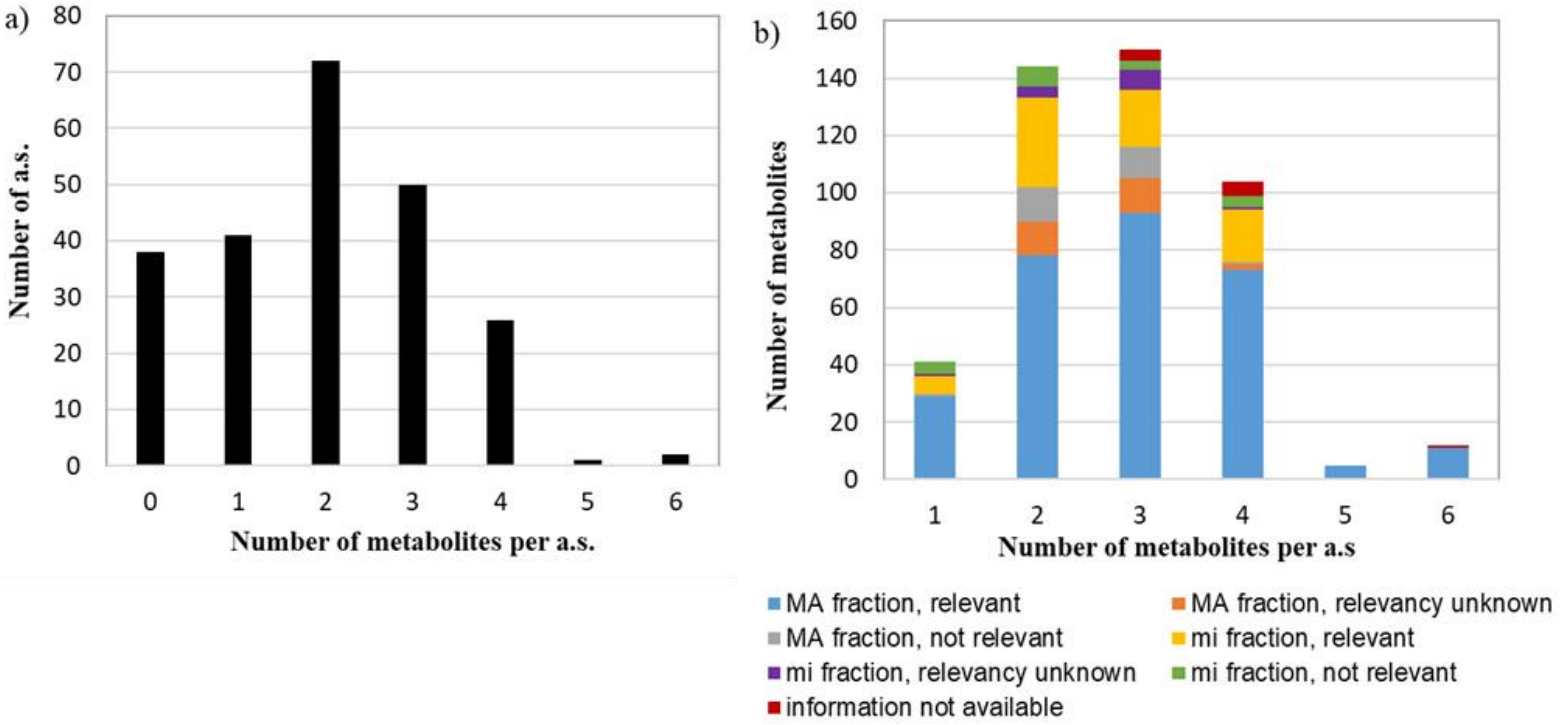
# Pesticide Representative uses - results

- 230 active substances (a.s.) ➔ human risks

| | Yes, known to cause a problem | No, known not to cause a problem | Possibly, status not identified | No data found |
|---|---|---|---|---|
| Carcinogen? | 12 (5%) | 126 (55%) | 81 (35%) | 11 (5%) |
| Mutagen? | 3 (1%) | 106 (46%) | 13 (6%) | 108 (47%) |
| Endocrine distrupter? | 8 (4%) | 55 (24%) | 42 (18%) | 125 (54%) |
| Reproduction/development effects? | 56 (24%) | 47 (20%) | 107 (47%) | 20 (9%) |
| Acetyl cholinesterase inhibitor? | 10 (4%) | 194 (85%) | 7 (3%) | 19 (8%) |
| Neurotoxicant? | 16 (7%) | 147 (64%) | 30 (13%) | 37 (16%) |
| Respiratory tract irritant? | 51 (22%) | 76 (33%) | 17 (7%) | 86 (38%) |
| Skin irritant? | 58 (25%) | 133 (58%) | 29 (13%) | 10 (4%) |
| Skin sensitiser? | 49 (21%) | 32 (14%) | 21 (9%) | 128 (56%) |
| Eye irritant? | 85 (37%) | 110 (48%) | 25 (11%) | 10 (4%) |
| Phototoxicant? | 1 (<1%) | 36 (16%) | 4 (2%) | 189 (82%) |

# Pesticide Representative uses - results

- 230 active substances (a.s.) ➔ metabolites



# Pesticide Representative uses - results

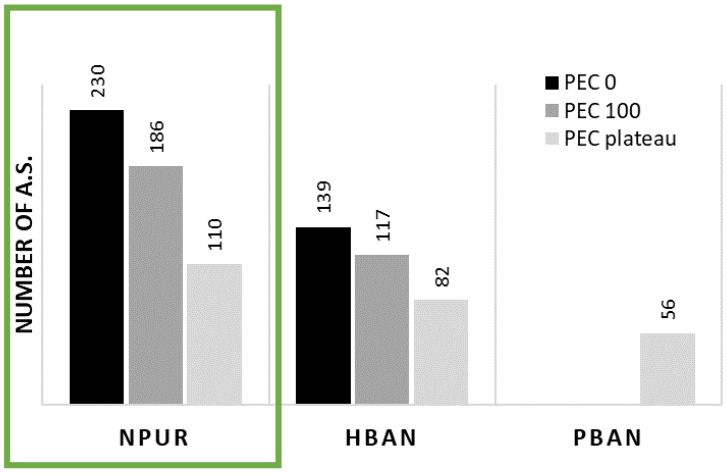
- 230 active substances (a.s.) ➔ pesticide input

| Crop | Parameter | NEU | CEU | SEU |
|---|---|---|---|---|
| **Cereals** | Number of a.s. | 77 | 51 | 88 |
| | Σ a.s. Applications (kg ha-1 year-1) * | 31 | 18 | 31 |
| **Dry Pulses-Vegetables-Flowers** | Number of a.s. | 49 | 30 | 68 |
| | Σ a.s. Applications (kg ha-1 year-1) * | 1,210 | 713 | 1,196 |
| **Grapes** | Number of a.s. | 40 | 19 | 56 |
| | Σ a.s. Applications (kg ha-1 year-1) * | 54 | 1,046 | 1,088 |
| **Grassland** | Number of a.s. | 8 | 7 | 8 |
| | Σ a.s. Applications (kg ha-1 year-1) * | 4 | 6 | 4 |
| **Maize** | Number of a.s. | 21 | 18 | 23 |
| | Σ a.s. Applications (kg ha-1 year-1) * | 8 | 7 | 9 |
| **Non-Permanent Industrial crops** | Number of a.s. | 28 | 18 | 32 |
| | Σ a.s. Applications (kg ha-1 year-1) * | 18 | 11 | 19 |
| **Permanent crops** | Number of a.s. | 29 | 9 | 39 |
| | Σ a.s. Applications (kg ha-1 year-1) * | 60 | 45 | 157 |
| **Root crops** | Number of a.s. | 58 | 30 | 64 |
| | Σ a.s. Applications (kg ha-1 year-1) * | 198 | 178 | 280 |

*conservative approach: assume all a.s. allowed per crop-region combination are applied, at the same time, and at their highest pesticide input scenario

# Pesticide Representative uses - results

## Predicted environmental concentrations in soil (PECs)




| Crop | Parameter | PEC 0 | | | PEC 100 | | | PEC plateau | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | NEU | CEU | SEU | NEU | CEU | SEU | NEU | CEU | SEU |
| **Cereals** | Number of a.s. | 77 | 51 | 88 | 60 | 40 | 67 | 37 | 22 | 41 |
| | Σ all a.s. PECs | 25.4 | 14.5 | 24 | 7.3 | 3.2 | 5.2 | 5.3 | 1.4 | 4.5 |
| **DPVF** | Number of a.s. | 49 | 30 | 68 | 40 | 23 | 53 | 26 | 14 | 30 |
| | Σ all a.s. PECs | 539.7 | 396.2 | 493.4 | 19.8 | 27.7 | 14.3 | 2.4 | 2.5 | 3.9 |
| **Grapes** | Number of a.s. | 40 | 19 | 56 | 33 | 15 | 47 | 28 | 10 | 37 |
| | Σ a.s. PECs | 22.4 | 182.6 | 196.8 | 9 | 4.8 | 10.1 | 4.7 | 2.1 | 5.4 |
| **Grassland** | Number of a.s. | 8 | 7 | 8 | 5 | 6 | 5 | 2 | 2 | 2 |
| | Σ all a.s. PECs | 2.9 | 6.5 | 2.9 | 0.6 | 0.8 | 0.6 | <0.1 | <0.1 | <0.1 |
| **Maize** | Number of a.s. | 21 | 18 | 23 | 14 | 12 | 16 | 4 | 4 | 5 |
| | Σ all a.s. PECs | 6.8 | 6.5 | 8.5 | 1 | 0.5 | 1.2 | 0.1 | 0.1 | 0.2 |
| **Non-Permanent Industrial crops** | Number of a.s. | 28 | 18 | 32 | 22 | 15 | 27 | 12 | 6 | 14 |
| | Σ all a.s. PECs | 16.3 | 11.6 | 20 | 5.5 | 3.9 | 6.8 | 1.3 | 1 | 1.5 |
| **Permanent crops** | Number of a.s. | 29 | 9 | 39 | 23 | 6 | 29 | 16 | 5 | 22 |
| | Σ all a.s. PECs | 19 | 19.9 | 85.3 | 6 | 7.2 | 6.9 | 2.7 | 1.8 | 3.2 |
| **Root crops** | Number of a.s. | 58 | 30 | 64 | 44 | 22 | 48 | 29 | 10 | 29 |
| | Σ all a.s. PECs | 92.8 | 61.5 | 195.9 | 19.5 | 5.8 | 19.3 | 1.9 | 0.8 | 1.9 |

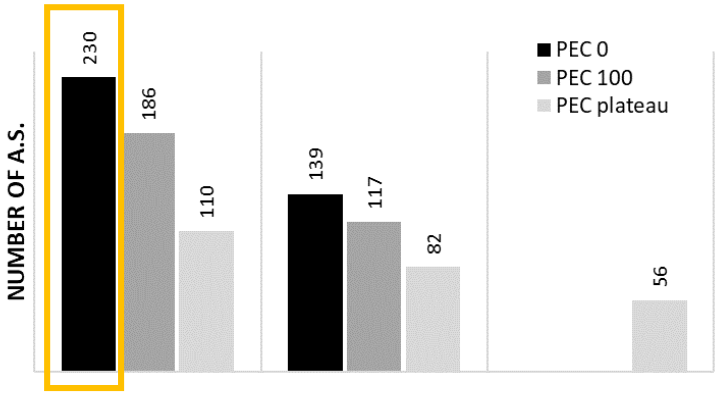


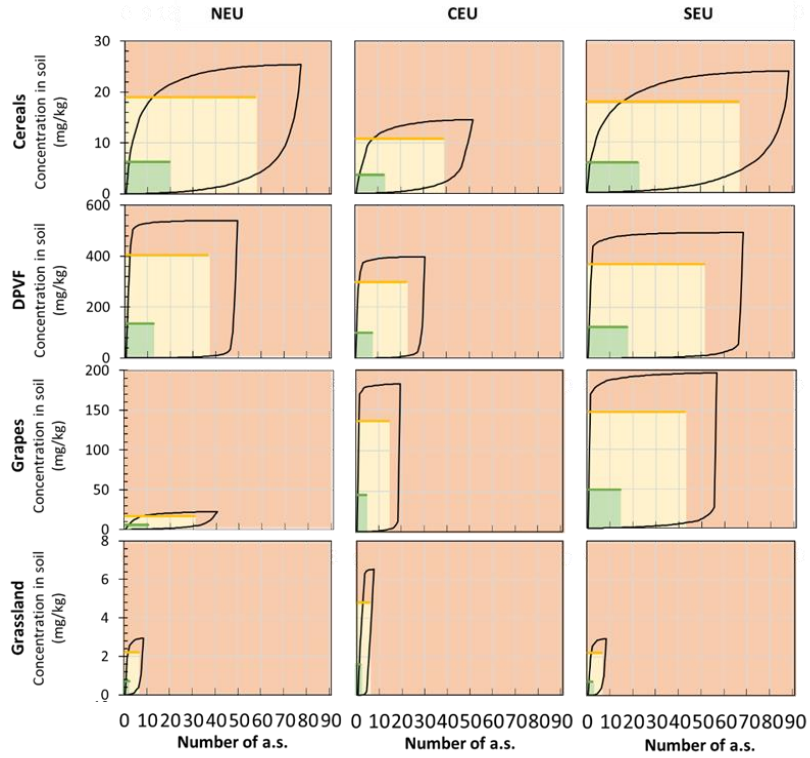
*DPVF: Dry pulses-vegetables-flowers; ** PECs unit: mg/kg

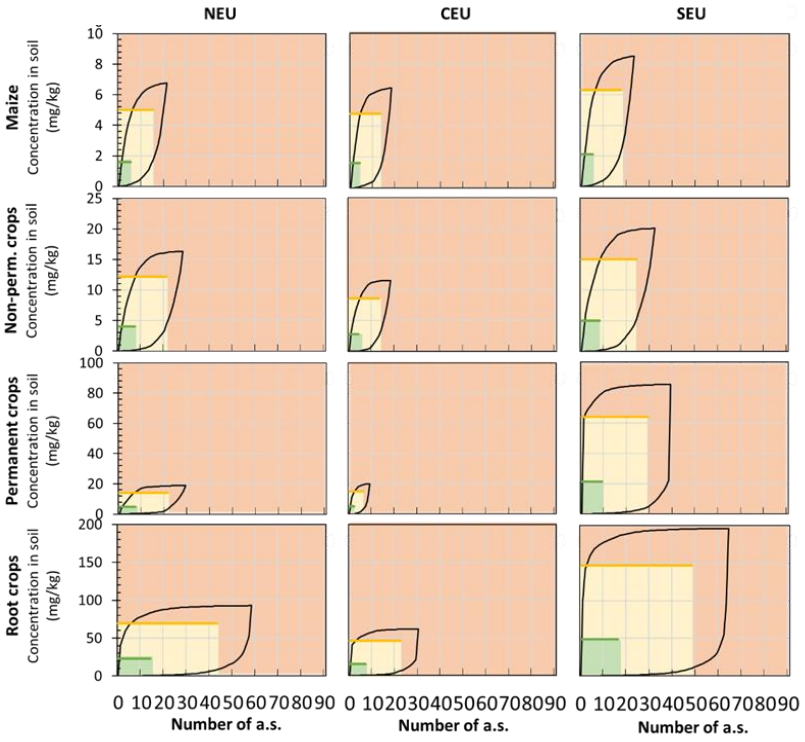
# Pesticide Representative uses - results

## Predicted environmental concentrations in soil (PECs)

With Predictions-based thresholds



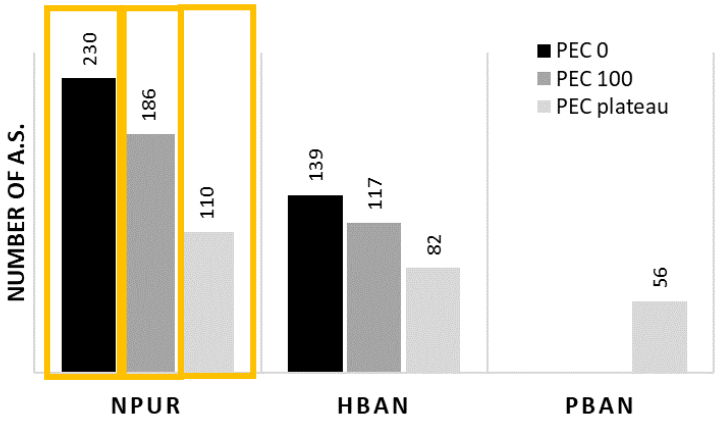



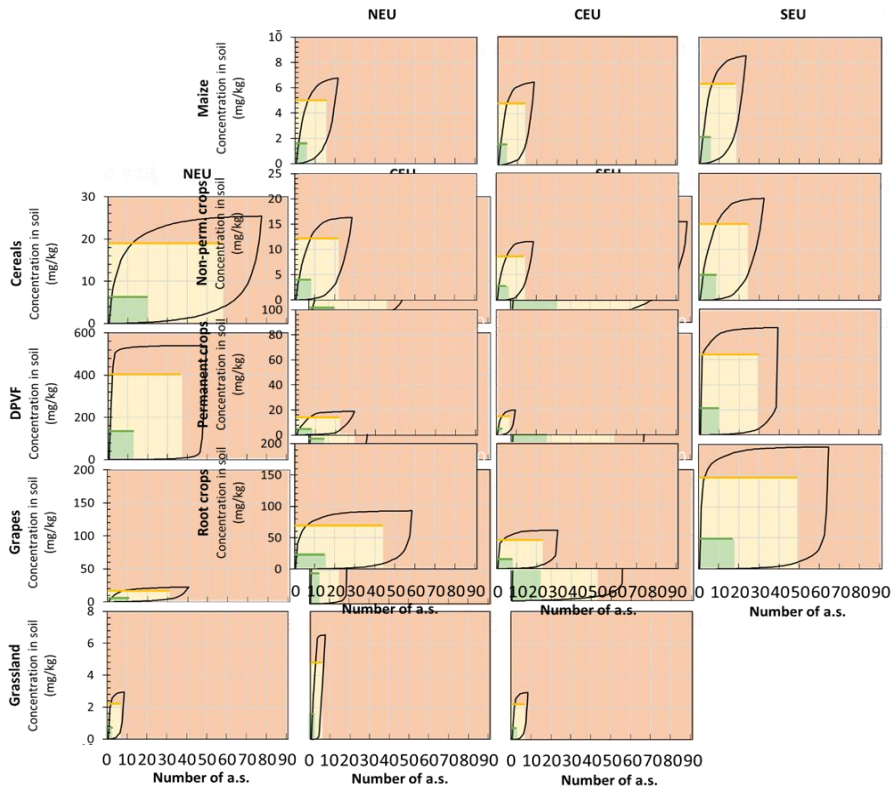



# Pesticide Representative uses - results

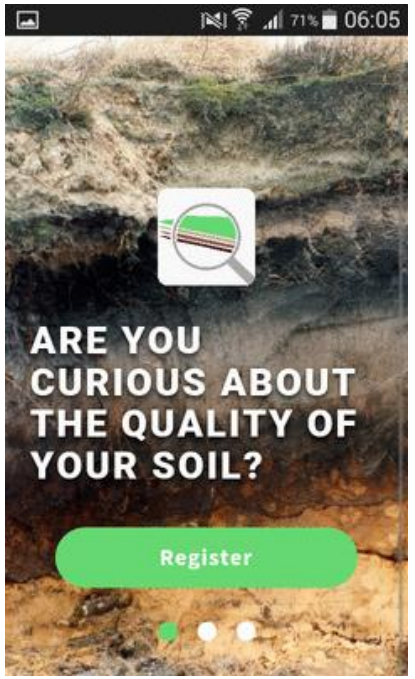
## Predicted environmental concentrations in soil (PECs)

With Predictions-based thresholds



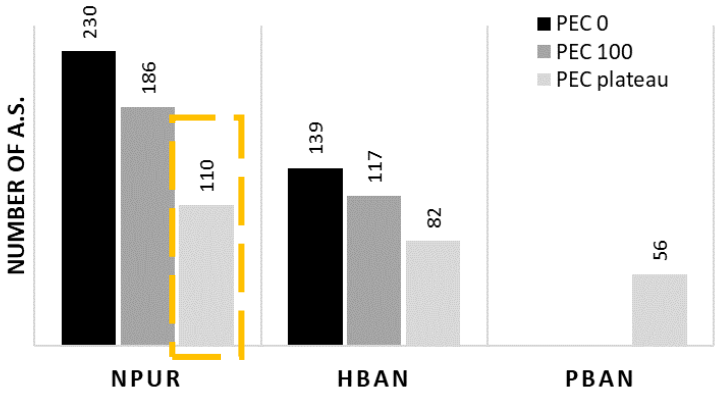



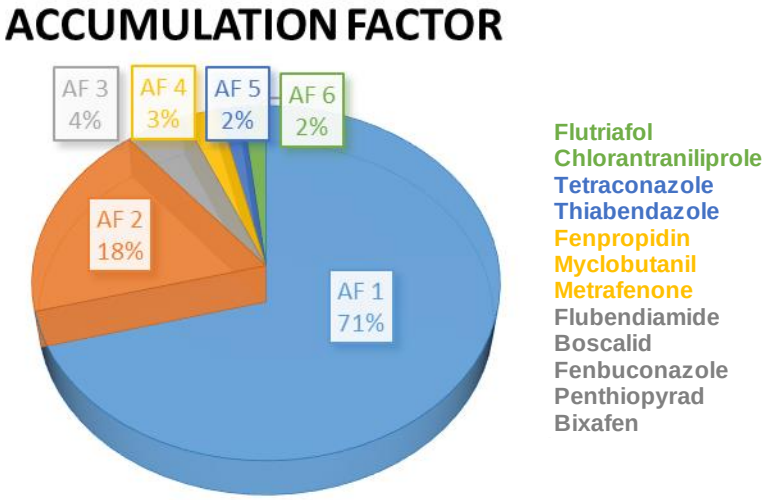

## Soil Quality Mobile App (SQAPP)



# Pesticide Representative uses - results

Predicted environmental concentrations in soil (PECs)

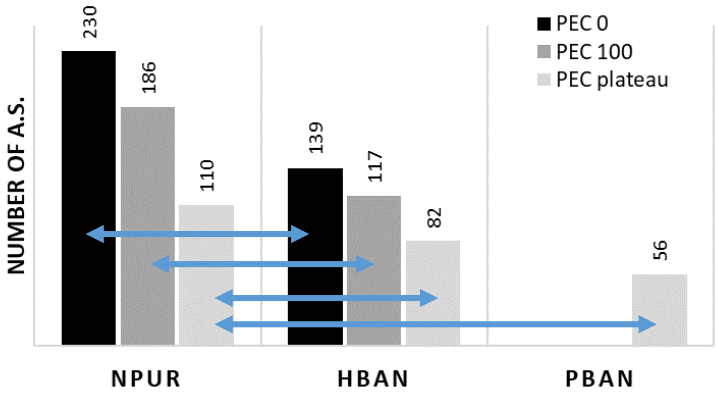



*Accumulation factor (AF)=PEC accumulated/PEC 0
*PEC accumulated=PEC0+PECplateau

# Pesticide Representative uses - results

## Predicted environmental concentrations in soil (PECs)

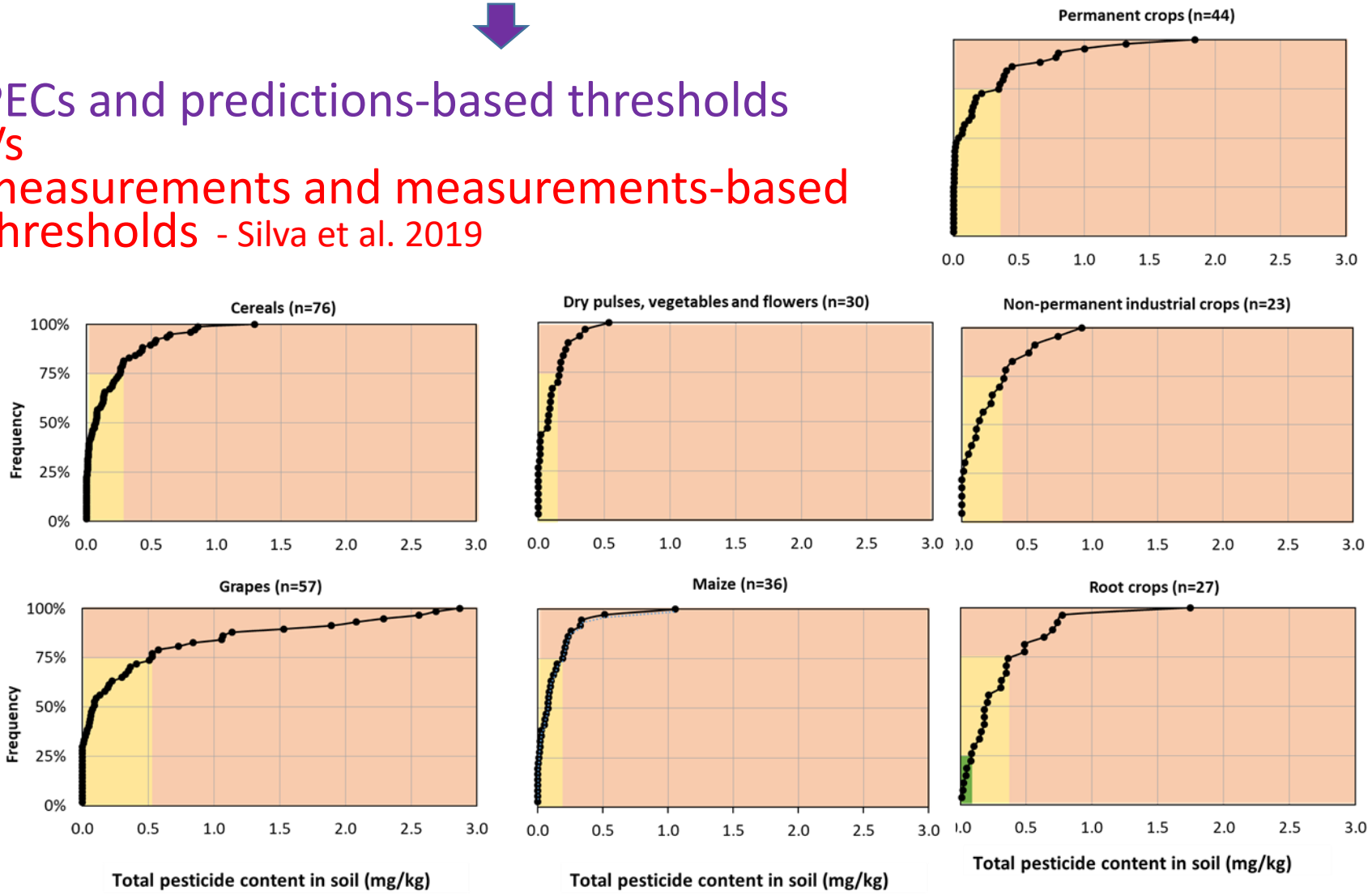



Average of NEU, CEU and SEU

| Crop | NPUR ==> Hban | | | | | | NPUR ==> Pban | |
|---|---|---|---|---|---|---|---|---|
| | PEC 0 | | PEC 100 | | PEC plateau | | PEC plateau | |
| | ↓ Number a.s. | ↓ ∑ a.s. input | ↓ Number a.s. | ↓ ∑ a.s. input | ↓ Number a.s. | ↓ ∑ a.s. input | ↓ Number a.s. | ↓ ∑ a.s. input |
| **Cereals** | 44% | 73% | 39% | 56% | 21% | 20% | 30% | 36% |
| **DPVF** | 24% | 3% | 20% | 17% | 21% | 31% | 49% | 44% |
| **Grapes** | 14% | 22% | 14% | 71% | 18% | 46% | 42% | 25% |
| **Grassland** | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| **Maize** | 82% | 96% | 88% | 96% | 62% | 38% | 85% | 70% |
| **NPIC** | 70% | 93% | 70% | 91% | 71% | 94% | 79% | 50% |
| **Perm. crops** | 13% | 25% | 17% | 52% | 19% | 48% | 54% | 46% |
| **Root crops** | 42% | 20% | 38% | 46% | 42% | 42% | 51% | 45% |

# Pesticide Representative uses - results

PECs and predictions-based thresholds
Vs
measurements and measurements-based thresholds - Silva et al. 2019



# Conclusions

- Unacceptable effects of currently use pesticides in non-target organisms
- Knowledge gaps for several endpoints (& no data for mixtures)
- Highest pesticides content:
  - in dry pulses-vegetables-flowers and grapes
  - in SEU
- Pesticide use restrictions leads to a substantial attenuation of soil contamination
- Predictions-based thresholds resulted in very low soil protection
- Harmonized pesticide use and distribution data is needed to validate PECs, and PECs derivate indicators, including Toxicity exposure ratios (TERs) used in pesticides approval process.

# Thank you
# for your attention!

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Interactive Soil Quality Assessment

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