Precision agriculture with variable rate and spot application

Calculation example and possible consequences for the risk assessment

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Outline

- Precision techniques for crop protection
- Use of reduced dose in Groundwater Risk Assessment?
  - Case study Groundwater Risk Assessment
    - Variable rate application
    - Calculations (method, input data)
    - Results
    - Conclusions
    - Consequences for Groundwater Risk Assessment
- Ecotox options for adapted in-soil organism RA

Precision techniques for crop protection

Plant receives pesticide treatment, based upon field-specific data, using the latest technology

Various drivers for precision application

- Ambition EU Farm to Fork strategy (Green Deal)
  - 50% less PPP in 2030
- Rapid technical advancements
  - smart scanning/full spray nozzle control

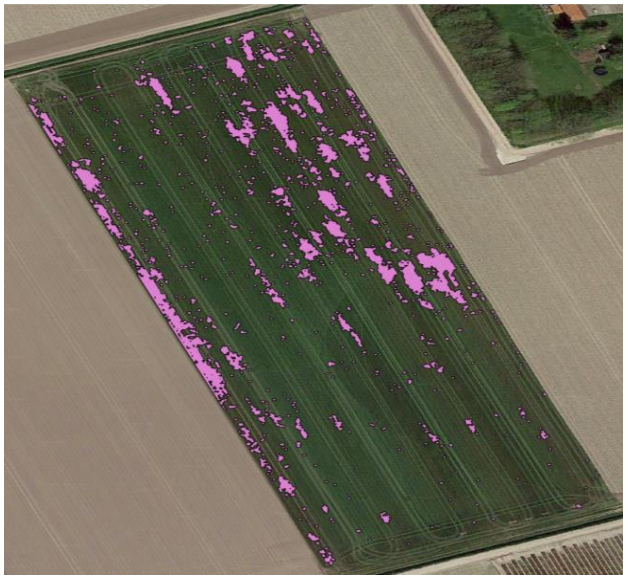
- Full digitalization of (local scale) crop management
  - inform farmers / consultants / risk assessors

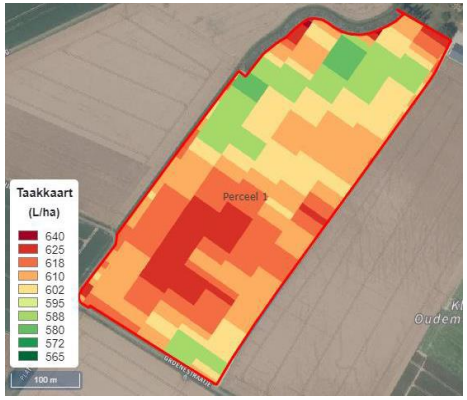
Precision techniques for crop protection

- Treatment to be determined per m^2 or per plant
- Spatial resolutions differ

Chained precision-applications

1. Biomass scan in potato field for a desiccant spray task





2. task map **variable rate applications** via spray boom nozzle sections

On-the-go application based on scan/drone images, of field thistle as weed
-> spot application

Source Boheemen et al., 2022

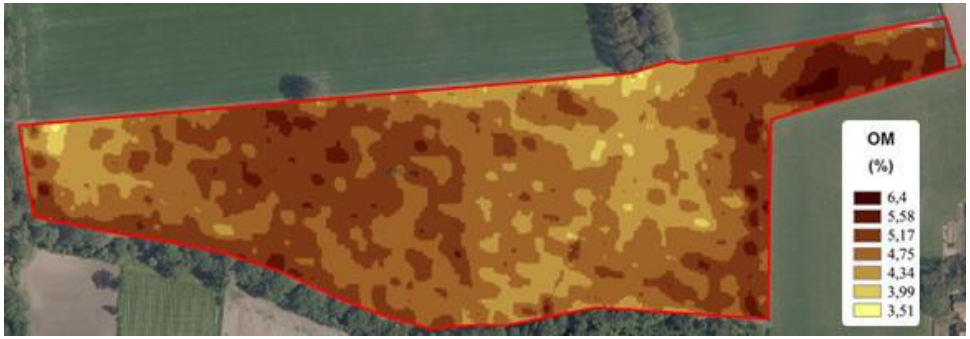
Precision techniques for crop protection

- At present, mainly used for variable rate application or spot application of herbicides
  - Herbicides for haulm destruction
  - Soil herbicides

Picture from akkerwijzer.nl

- Sensors making variable rate or spot application possible
  - Biomass sensors (herbicides for haulm destruction or targeting specific weeds)
  - Sensors for making soil scans to map spatial variability of soil properties (soil herbicide).

Maps can also be based on drone- or satellite images



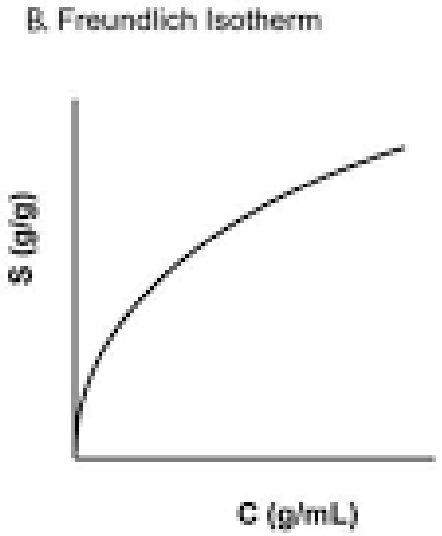
Van Boheemen et al., 2022

Use of reduced dose in Groundwater RA?

- ERA for PPP registration in EU and NL: homogenous pesticides application according the advised dose is assumed.
- No guidance on how to assess precision applications in the current evaluation methods
- Possible option: include reduced dose as result of precision applications as a mitigation option in GW RA
    - If precision application technique leads on average to using 40% of advised dose (60% reduction) –> perform risk assessment using 40% of advised dose
- Underlying assumption: risks are averaged out over the entire field – Is this justified?

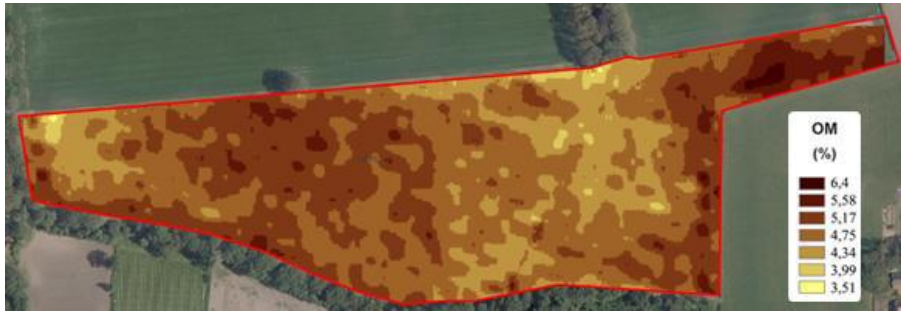
Use of reduced dose in Groundwater RA?

- **Selected case:** Groundwater risk assessment and variable rate application based on measured organic matter content
- EU GW endpoint: 80th percentile leaching concentration at 1 m depth below a treated field; spatial unit = field
- **Hypothesis**: For substances with non-linear sorption risks are not averaged out over the field.
  - Use of average applied reduced dose on the field does NOT result in a leaching concentration that is the same as the area weighted average leaching concentration as result of a series of different dose applications applied per patch in the field.



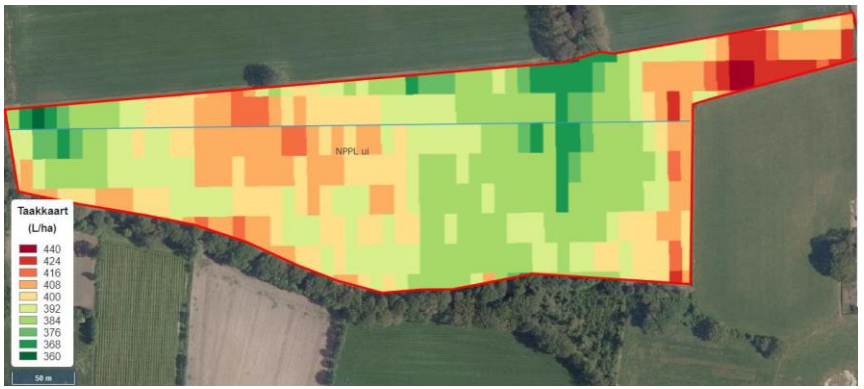
Case study GW RA – Variable rate application

- Variable rate applications of (soil) herbicide on 8.3 ha field with seed onions
- Soil scan: organic matter content (OM) in top 30 cm



- Decision model Kempenaar et al. 2013 used: $Dose_{(min,max)} = a \cdot OM + b$
  - average of the minimal effective dose: 1.38 L (product)/ha
    - ~35% of advised dose (4 L/ha, so ~ 65% reduction)
  - with a maximum of 1.54 L/ha and a minimum of 1.13 L/ha

- Task map of spraying volume made



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Case study GW RA – Calculation method

- For each of 164 patches 1 PEARL simulation with dose of active ingredient specific for each patch
- SWAP/PEARL not parameterized for specific field – FOCUS GW Kremsmünster scenario taken
  - However, measured organic matter content of top 30 cm used (patch specific)
- Result: 164 80th percentile leaching concentrations at 1 m depth
  - Calculate area weighted average 80th perc. leaching conc.
- Compare with 1 PEARL simulation for Kremsmünster scenario using the reduced dose (35% of advised dose):
  1. Area weighted OM of field of case study (4.7%)
  2. OM Kremsmünster scenario (3.6%)

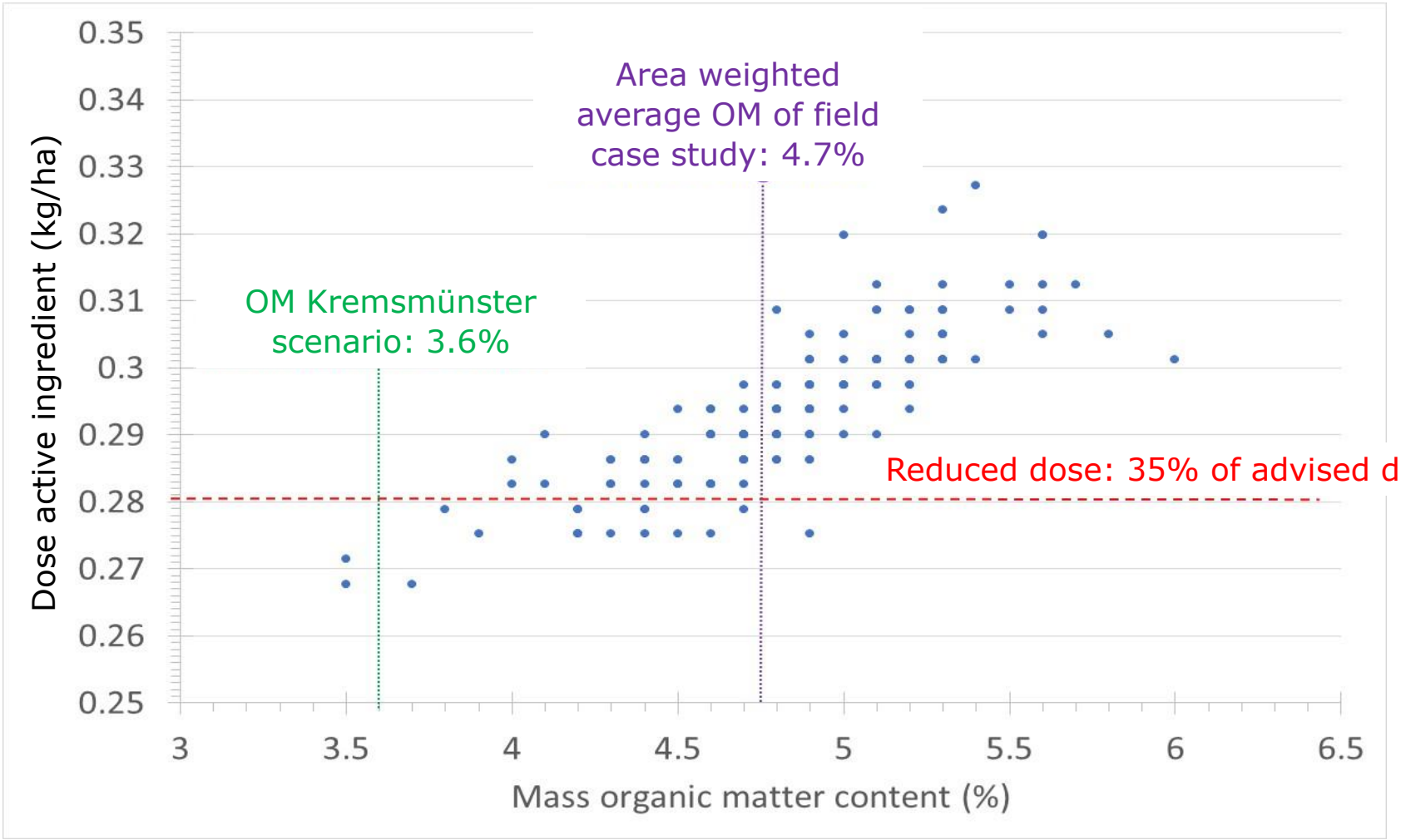
Case study GW RA – Calculation input

- a.i. → Kom_{soil} : 66 L/kg, N: 0.965, $DegT50_{soil}$: 13 d
- Task map: spraying volume of PPP for each patch of treated field, calculated back to dose PPP and dose of active ingredient
- For each patch the area (1.6 – 7146 m^2) and the average soil organic matter content of the top 30 cm soil (3.6 - 6%)

Patch ID	Average soil organic matter content of the top 30 cm (%)	Area of the patch (m^2)	Spraying volume (L/ha)	Dose PPP (L PPP/ha)	Dose active ingredient (kg a.i./ha)
1	3.7	180.49	360	1.2600	0.2678
2	3.5	24.40	360	1.2600	0.2678
3	3.5	617.05	365	1.2775	0.2715
.					
.					
162	5.6	437.96	430	1.5050	0.3198
163	5.3	240.49	435	1.5225	0.3235
164	5.4	226.34	440	1.5400	0.3273

Case study GW RA – Calculation input

Relationship between dose and the mass organic matter fraction



Case study GW RA - Results

164 PEARL simulations • Kremsmünster scenario • Patch specific OM • Patch specific dose	1 PEARL simulation • Kremsmünster scenario • Area weighted average OM of field of case study • Reduced dose (35% of advised dose)
area weighted average of 80th percentile leaching concentration (µg/L)	80th percentile leaching concentration (µg/L)
2.47E-4	2.25E-4

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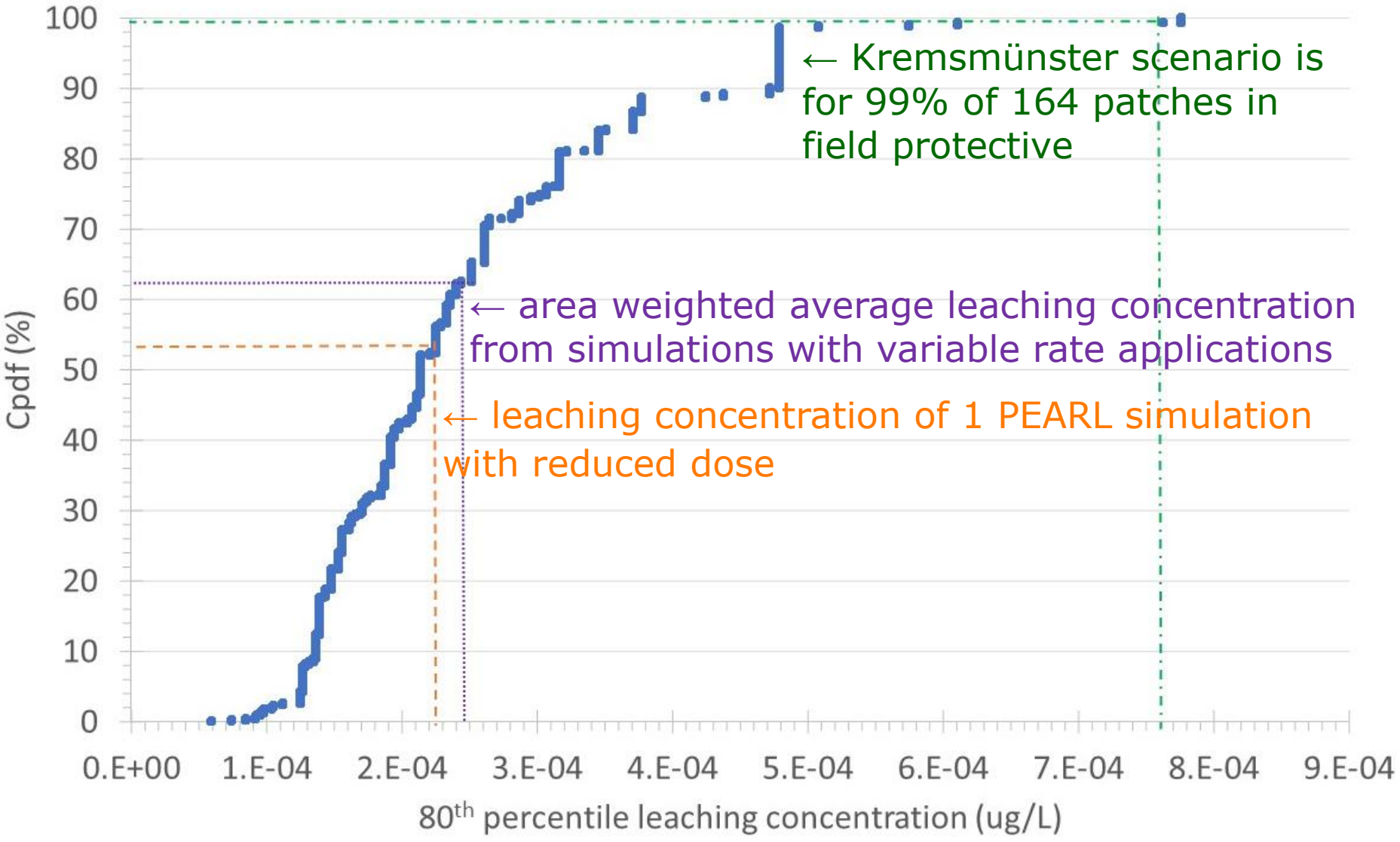
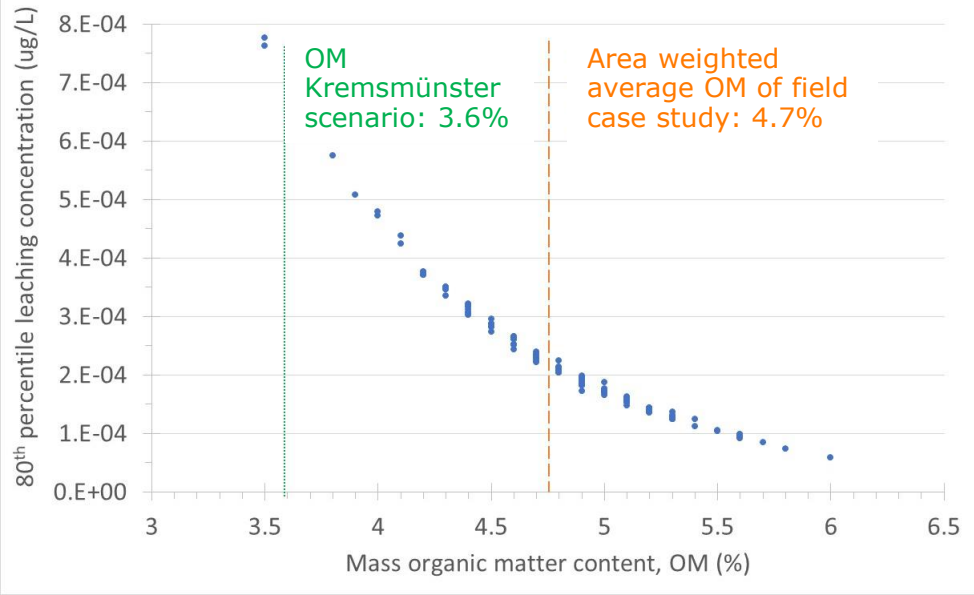
Case study GW RA - Results

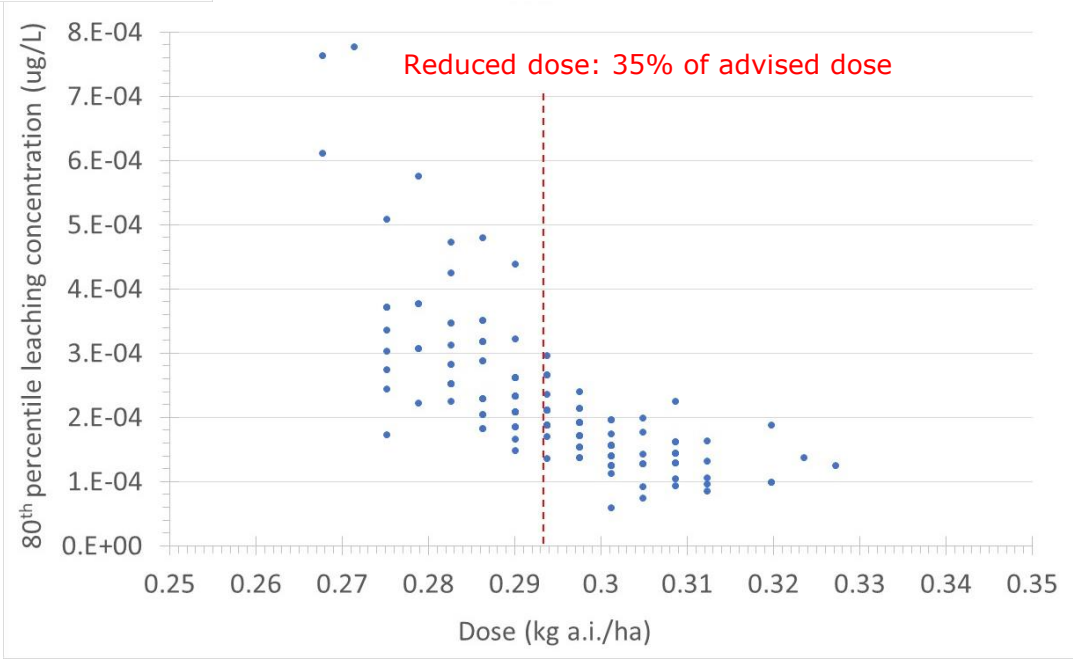


Case study GW RA - Results



slightly mobile a.i. (Kom_{soil} 66 L/kg)

-> organic matter driving factor for leaching concentration



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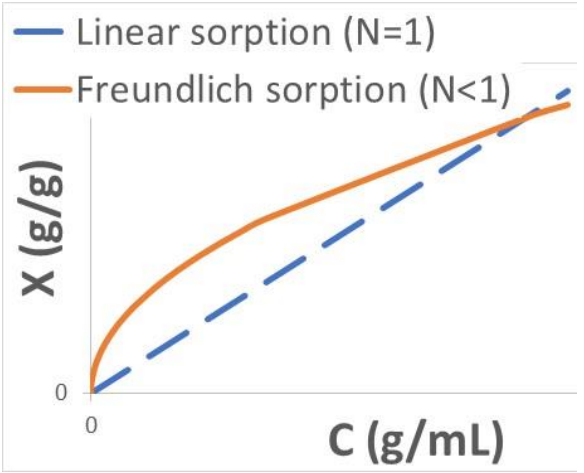
Case study GW RA - Conclusions

Hypothesis: For substances with non-linear sorption risks are not averaged out over the field

Case study: Using average reduced dose → slightly lower concentration than area weighted average concentration from the 164 simulations with variable rate applications

- Small difference due to rather weak non-linearity of sorption of a.i. (Freundlich coefficient 0.965).
- Substances with stronger non-linearity of sorption will show larger differences



Case study GW RA – Consequence for RA

- Can the reduced dose based on organic matter content of a specific field be used in the current (field scale) Groundwater RA?

Not recommended as reduced dose is very site specific.

- Reduced dose is determined for a specific field, taking into account:
    - Soil
    - PPP
    - Crop type
    - Pest pressure
    - Maximum dose (can be farmer input, but limited by advised dose)

Ecotox options for adapted in-soil organism RA

Large PEC_{soil} variation may influence RA of **in-soil invertebrates**
Irrelevant for most herbicide, but of interest for nematicides…?

Variable rate application:
- *Minor PEC_{soil} variations expected. RA likely follows GAP dose*

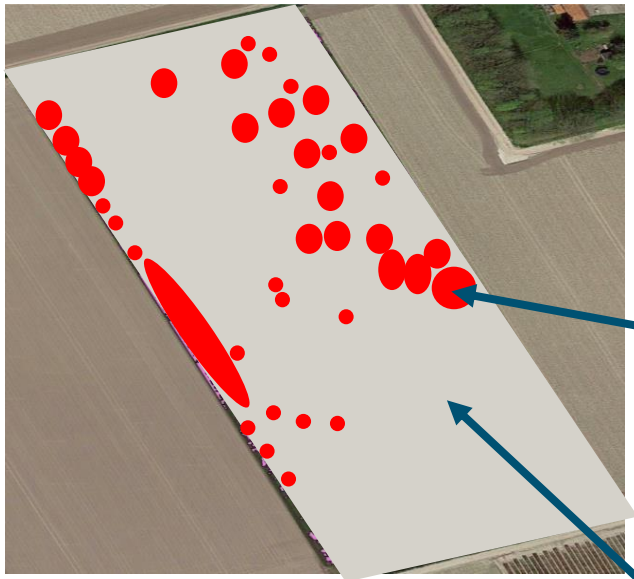
Spot application:
- *Part in-field is without application. Define specifics on label*

- **In soil risk assessment** (current):
  - Focus on very low dispersal capacity of soil organisms
  - PEC_{soil} >5x lower than chronic No Observed Effect Concentr.

- **Ecosystem Services-based risk assessment** (future*?):
  - Focus on recovery potential of Service Providing Units (SPUs)
  - Small effects may be tolerated, for a defined period

* EFSA Scientific Opinion 2017, 15(2):4690

Ecotox options for adapted in-soil organism RA
Spot application as part of in-soil RA?



Key question:

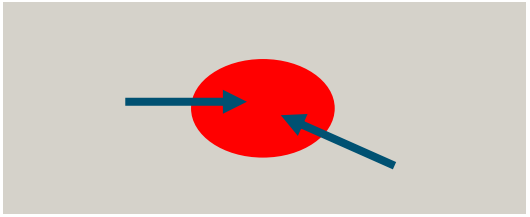
- Can spot-application enhance recovery potential of in-soil inverte-brates via dispersal within the field?

Treated patches,
If small/medium effect allowed:
ensure recovery!

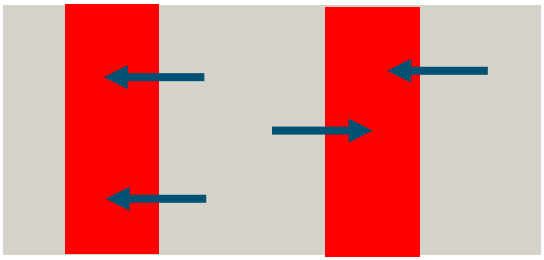
Non-treated area,
Is this a healthy population:
Suitable source for recovery?

Ecotox options for adapted in-soil organism RA
Spot application as part of in-soil RA?

spots



Also
Band/furrow/strip ?



To be clarified, research needs to:

- Define maximum patch radius for the most vulnerable in-soil SPU
- Define the maximum patch area to be repopulated (source-sink cap.)
- Healthy in-field population during full crop-season (in non-treated area):

Can negligible impact from full PPP scheme (apart from spot application) be shown?

Can these limitations be checked during precision application with on-the-go detection?

Thank you for your attention

Any questions?

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Literature

- Boheemen, K. van, Riepma, J. & Huijsmans, J.F.M., 2022. Precision Agriculture and Crop Protection. Definitions and the relation between precision-applications and the authorisation procedure of PPPs. Wageningen Research, Report WPR-1118. https://doi.org/10.18174/566499 in prep
- Kempenaar, C.; Heijting, S.; Kessel, G.J.T.; Michielsen, J.G.P.; Wijnholds, K.H. 2013. Modellen en beslisregels voor variabel doseren van gewasbeschermingsmiddelen op basis van variatie in bodem en gewas. Rapportage PPL-project 80. PRI-WUR Rapport 496b