An example how to combine glyphosate sorption and degradation parameters to soil data in scenario simulation

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Content

Background

- Introduction
- Glyphosate sorption and degradation
  - Sorption and soil properties
  - Degradation
    - Our observations in modelling studies
    - Literature: Relation between sorption and degradation

Used method

- different degradation rates for adsorbed and dissolved phases
- the same rates for different soils, but the proportions of dissolved and adsorbed phase vary with soils
- Sorption parameters related to soil P-status

Discussion

- Benefits and uncertainties of the used method

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Introduction

- Jaana presented yesterday the study of glyphosate fate in Southern Finnish conditions.
- Simulations are supposed
  - to extend and extrapolate measured data
  - to enable scenario testing (e.g. different application patterns)
- But… How to parametrize the scenarios?
  - (Hydrology parameters from Footprint + selected adjusted values based on previous calibrations)
  - Sorption and degradation parameters the most essential compound specific parameters in fate simulations
    - K_F has been determined for several Finnish soils – and shown to be linked with soil Phoshporus status in Finnish soils
    - No lab-studies on degradation in Finnish soils; a few field experiments => estimated dissipation rate

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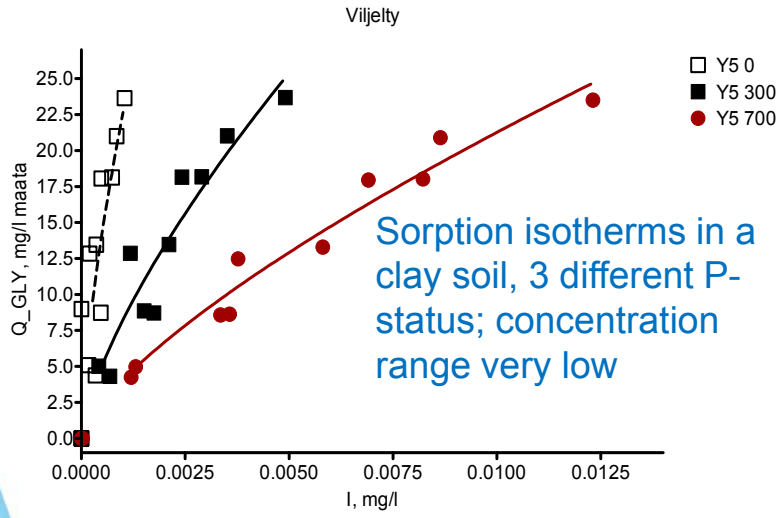
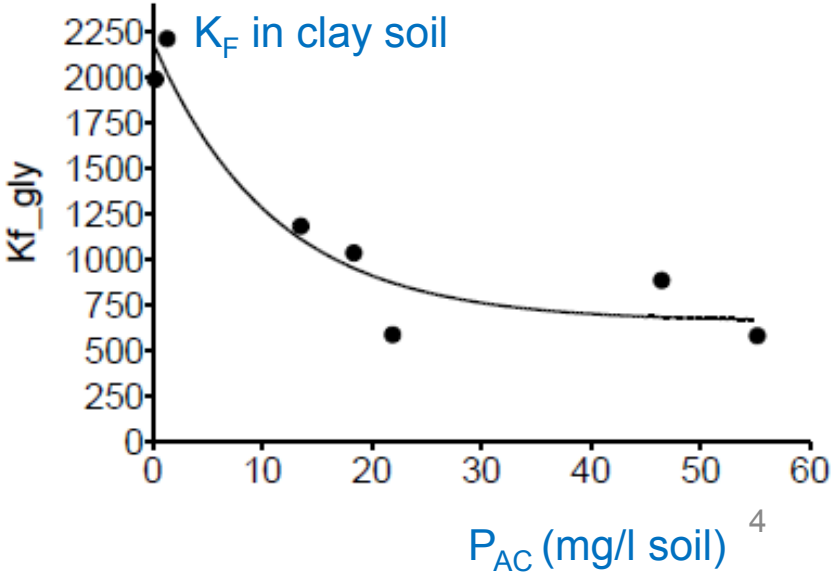
Background:
Glyphosate sorption into Finnish soils

- Glyphosate sorption coefficient is related to Finnish measure for the crop available P (P_{AC} = acid ammonium acetate extracted Phosphorus)
- => K_F can be estimated from P_{AC}
  - P_{AC} is easily available, because farmers are supposed to measure it every 5 years (as a part of environmental substitute program)
- E.g. Uusitalo 2014 (non-published)

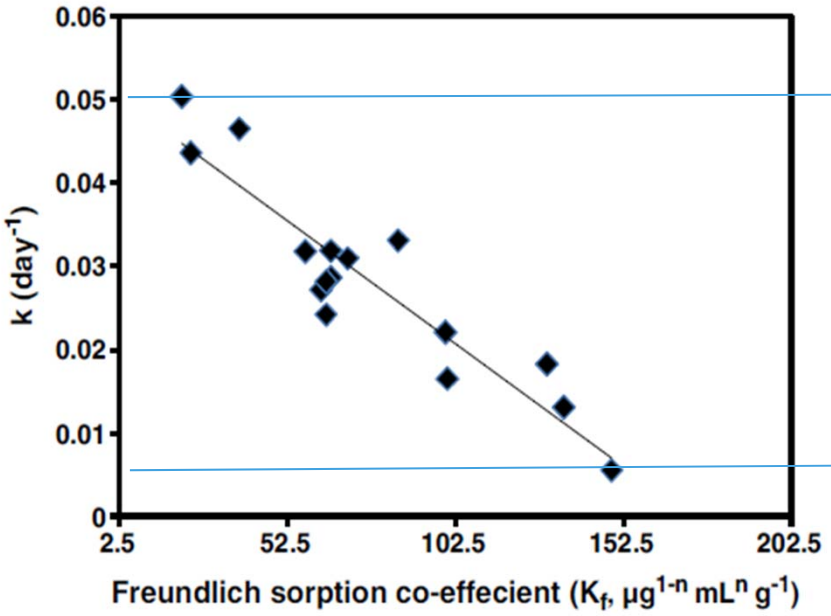


Sorption isotherms in a clay soil, 3 different P-status; concentration range very low



Background:
Adsorbed glyphosate is not readly bioavailable

- Glyphosate dissipation is due to microbiological degradation.
- Adsorbed glyphosate is not as bioavailable as dissolved glyphosate. =>Degradation and adsorption are correlated.
- E.g. **Ghafoor et al. 2011**. Science of the Total Enviroment 409: 1900-8.



DT50 = 14 days

DT50 = 116 days

Fig. 2. Relationship between the degradation rate constant k (day^{-1}) for glyphosate and the Freundlich sorption coefficient (K_f, $\mu g^{1-n}\ mL^n\ g^{-1}$).

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Degradation rates belong to the most essential parameters in simulations, when glyphosate fate after spring and fall applications should be compared

- In MACRO-model degradation rate (at ref. T and moisture)
  - separately for each 4 phases (micro & macropores; adsorbed and dissolved)
  - But often the same value is used for all phases (FOCUS + no data)
  - Different values can be given to each soil layers, but decreasing with depth can be obtained according to FOCUS-advices
  - Temperature decreasing and soil drying decreases the rate

  - In our inverse modelling study, only one rate parameter was varied (surface layer, same value for all phases) and all other rate parameters were calculated from it.
    - The goodness of fit values (Nash-Sutcliffe) were calculated for each simulation by comparing observed values and simulated values.

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Background:
An observation from our simulation studies

We used **inverse modelling to calibrate** glyphosate **degradation rate** (previously calibrated hydrology).

- We had data from two Finnish experimental fields

We obtained **different degradation rates depending on the object function**

- when based on concentrations in soil => slow degradation
- When based on concentrations in surface runoff and in drainage water => quick degradation

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Results = Method

Soil P-status => glyphosate K_F => DT50

- Different degradation rates for glyphosate in adsorbed and in dissolved phases (but still equilibrium sorption)
  - The simulation of Toholampi ”validation data set” improved (DT50dissolved = 10 days (= DT50water); DT50adsorbed = 100 days)
  - on-going testing with Kotkanoja data
- The same degradation rates (at reference conditions) in all soils, values separately for dissolved and sorbed phases (depth, T and moisture effect according to FOCUS).
  - Perhaps not valid assumption into different soils, but soils in scenario simulations are rather similar

=>

- Sorption coefficient determines the total degradation by dividing glyphosate to the fast degradable (dissolved) and slowly degradable (adsorbed) phases
- The KF is calculated from soil P_{AC}
  - Freundlich exponent term not allowed to vary

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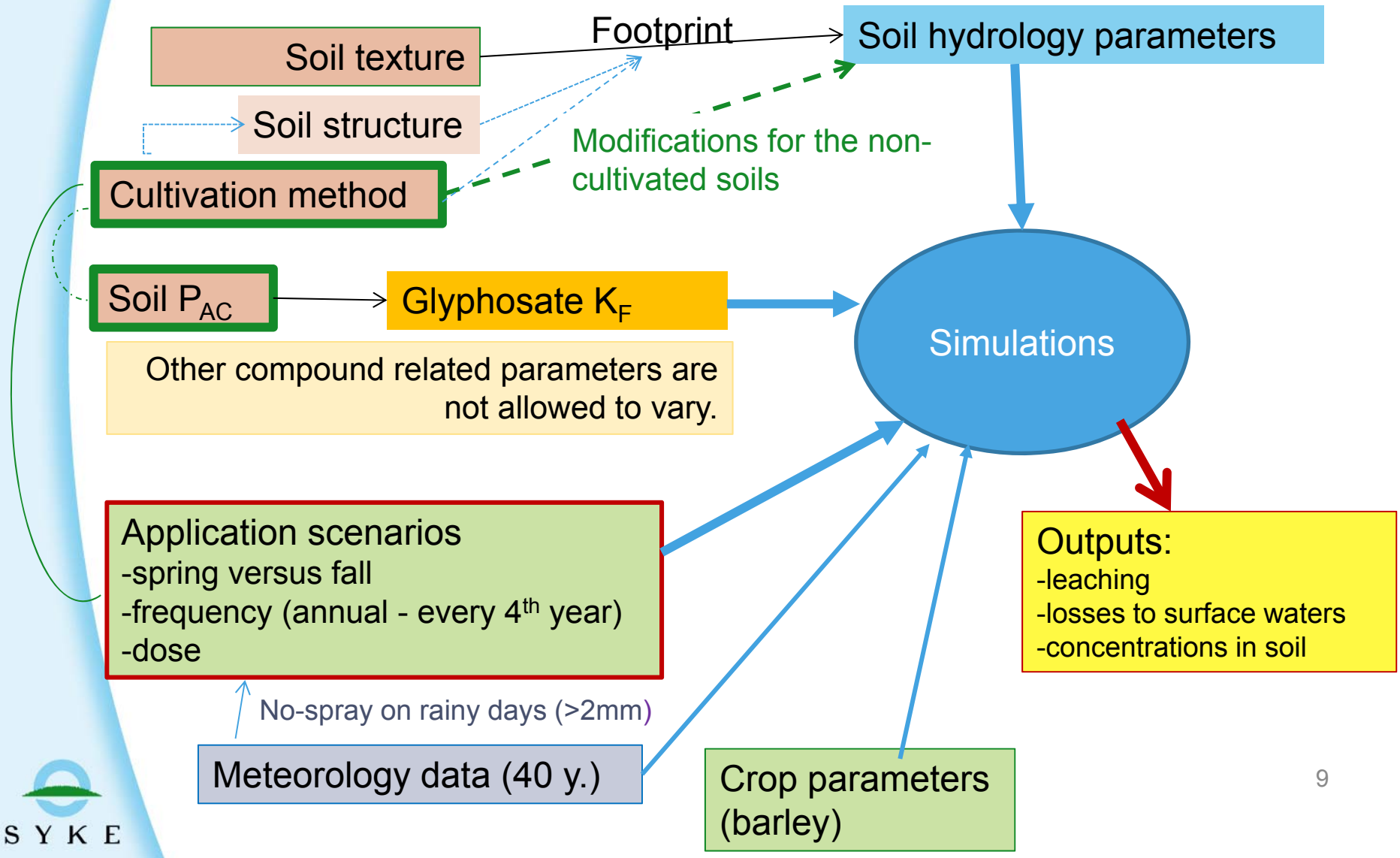
Scenario parametrization



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Discussion
Benefits and uncertainties

- Separate degradation rates in adsorbed and dissolved phase improved simulation (in the calibration site).
- The method seems to have sensible bases and it decrees the number of varying parameters in scenarios => easier to perform simulations

- However, the method has not been tested against measured degradation data.
- Could the method be used in other areas?
- The correlation between glyphosate Freundlich sorption coefficient and P_{AC} has been just curve fitting. Risto and Pirkko used different soils and different concentration areas and got a different curves.
  - The P_{AC} suits to describe the P-status in Finnish soils (young soils, usually low pH and only minor part of soil total P is available for crops) but other P-status measures are used in other countries (not directly transformable)

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The study is on-going.

Tips and warnings are welcome!

Thank you!

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Unto Nikunen is bottling sampled water for residue analysis in Toholampi experimental field (sandy loam soil).