

## Measuring and modelling pesticide leaching in macroporous soils along a hillslope

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# Background

- » Despite rigorous registration procedure still pesticides found in groundwater

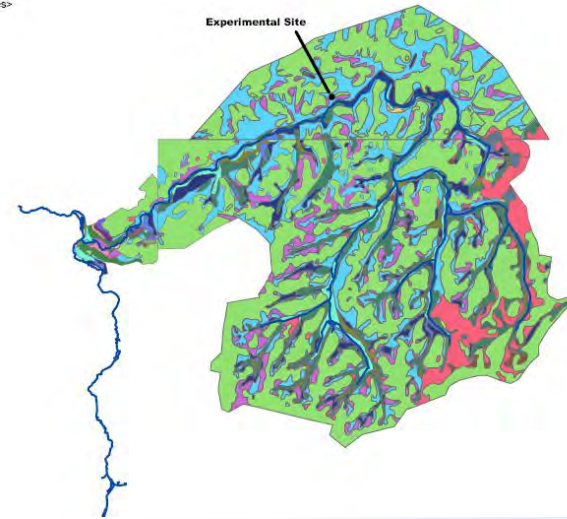


(VMM, 2010)

- » Several reasons: historical burden, accidental, leaching
- » This study: extensive and detailed monitoring of hydrological soil processes and pesticide concentrations to investigate processes controlling pesticide movement to groundwater







# Field site

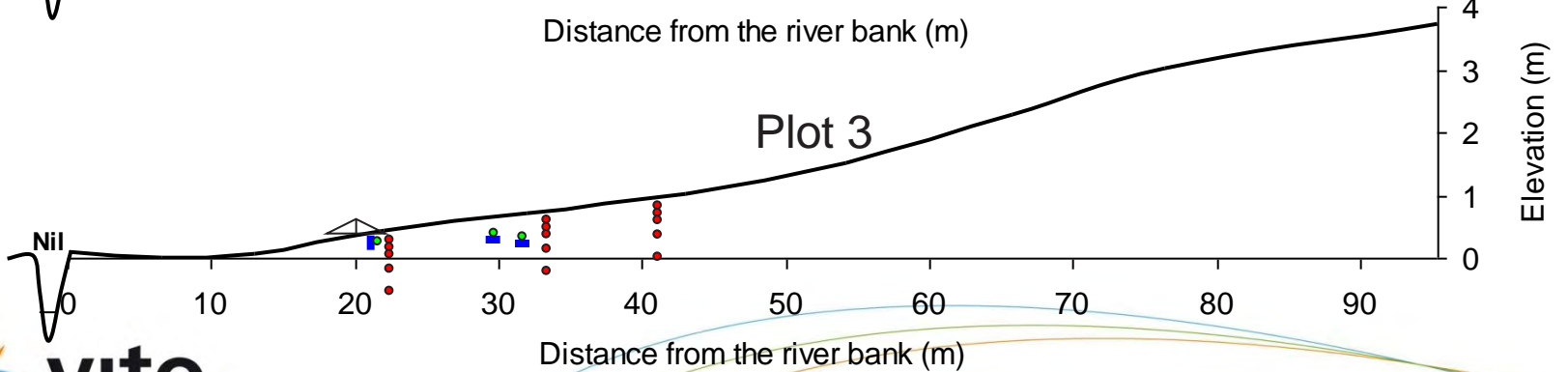
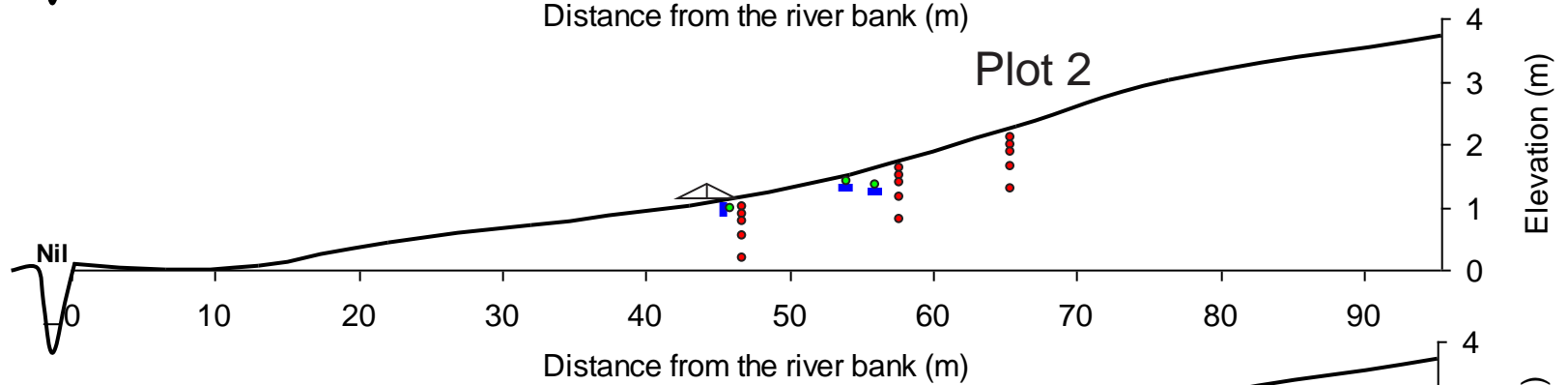
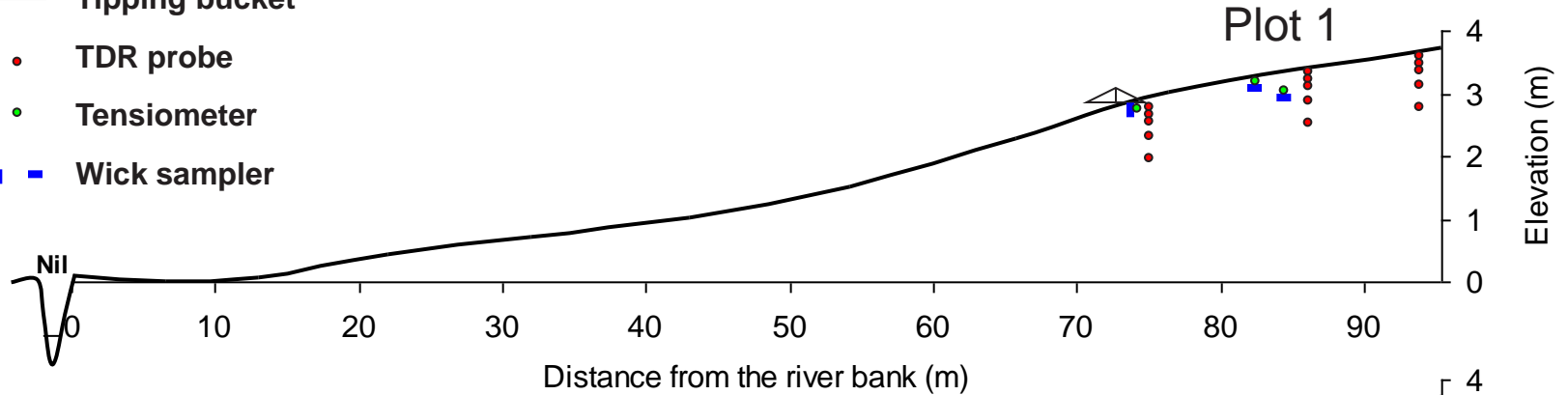


Nil-Saint-Martin  
 Hillslope: 80 x 10 m; Slope 5%  
 Loamy soil



# Plot set-up

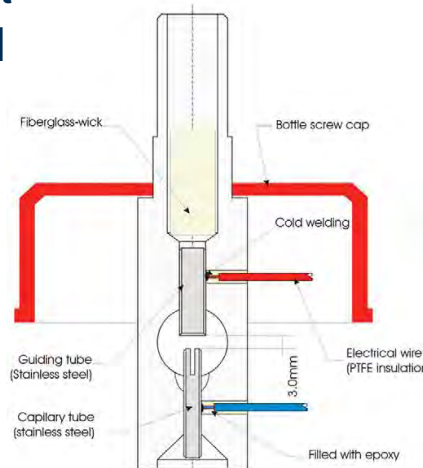
-  Tipping bucket
-  TDR probe
-  Tensiometer
-  Wick sampler





# Site equipment

- » meteo-station: air temperature, relative humidity, wind speed, rain gauge
- » 3 surface runoff plots (2 m 22/50/75 m)
- » 45 TDR probes (9 locations; 10, 20, 30, 40, 50 and 100 cm depth)
- » 9 wick samplers (horizontally at 24 and 40 cm, vertically at 1-31 cm)
- » 9 tensiometers (5 cm from the wick sampler)
- » time resolution: meteo & fluxes every 15 min; soil moisture content and pressure head hourly



# Field installation





# Datalogging & - transmission



# Web service

<http://vastesensoren.rma.vito.be:8080/VasteSensoren/faces/jsp/sensorType.jsp>

**Water sensors for Agriculture**

Home | Sensor data | Help | Contact

Logged in: [ ]

Select sensor plots

The agricultural field is a mildly sloping field close to a surface water, cropped with maize. Please click on the map to select a sensor plot. Use CTRL-click to select more than one plot. The plots can also be selected in the list at the right.

| Sensor Plots |             |
|--------------|-------------|
| Name         | Location    |
| Plot1        | Up hill     |
| Plot2        | Middle part |
| Plot3        | Down hill   |

Map: [Aerial view of a field with three yellow markers indicating sensor plots.]



# Soil properties

| Location | Depth cm | Clay % | Silt % | Sand % | Org. matter % | pH H <sub>2</sub> O |
|----------|----------|--------|--------|--------|---------------|---------------------|
| P1       | 0-30     | 24.7   | 65.3   | 10.0   | 1.6           | 7.8                 |
|          | 30-100   | 23.3   | 70.5   | 6.3    | 0.3           | 7.7                 |
| P2       | 0-32     | 16.2   | 74.9   | 8.9    | 1.2           | 7.8                 |
|          | 32-100   | 20.9   | 72.8   | 6.3    | 0.2           | 7.6                 |
| P3       | 0-30     | 12.4   | 77.0   | 10.5   | 0.9           | 7.6                 |
|          | 30-100   | 9.7    | 79.9   | 10.4   | 0.3           | 7.6                 |

# Pesticide properties

|             | Name                    | K <sub>oc</sub> (l kg <sup>-1</sup> ) | DT50 (d)                       | H' (-)                               |
|-------------|-------------------------|---------------------------------------|--------------------------------|--------------------------------------|
| Substance 1 | fluroxypyr              | 194.7<br>moderately<br>mobile         | 51<br>moderately<br>persistent | 1.69 <sup>E-10</sup><br>non-volatile |
| Substance 2 | mesosulfuron-<br>methyl | 92<br>moderately<br>mobile            | 78<br>moderately<br>persistent | 1.50 <sup>E-15</sup><br>non-volatile |
| Substance 3 | metsulfuron-<br>methyl  | 39.5<br>mobile                        | 10<br>non-persistent           | 6.17 <sup>E-15</sup><br>non-volatile |

PPDB (2009). The Pesticide Properties Database (PPDB) developed by the Agriculture & Environment Research Unit (AERU), University of Hertfordshire, funded by UK national sources and the EU-funded FOOTPRINT project (FP6-SSP-022704).

# Evidence of macropores

## » Visual inspection



**P1**

**0-50 cm**



**50-100 cm**

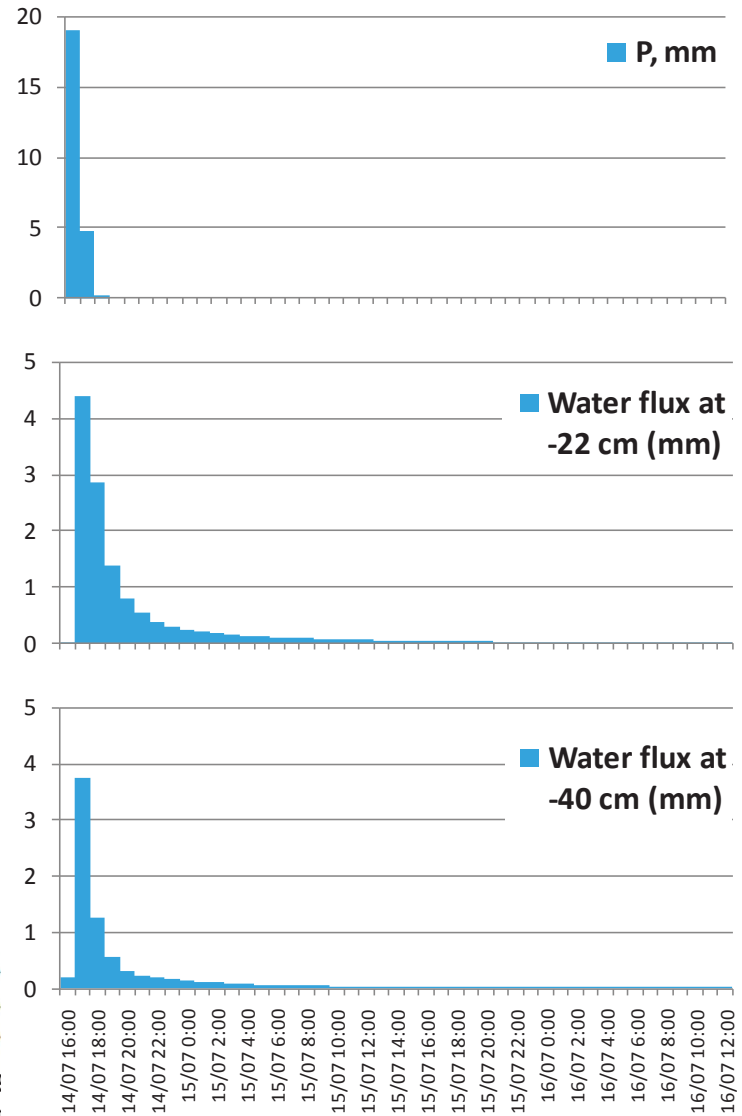


# Evidence of macropores

- » Visual inspection
- » Discrepancy between  $\theta_{\text{TDR}}$  and  $\theta_{\text{gravi}}$  (Tang et al., 2011)
  - » high spatial variation in soil moisture measurement in ring samples
  - » at a depth of 10 cm and 20 cm 46% and 65% resp. of measurements  $\theta_{\text{gravi}}$  3% volumetric water content higher than  $\theta_{\text{TDR}}$
  - » at a depth of 30 cm and 50 cm still 6%

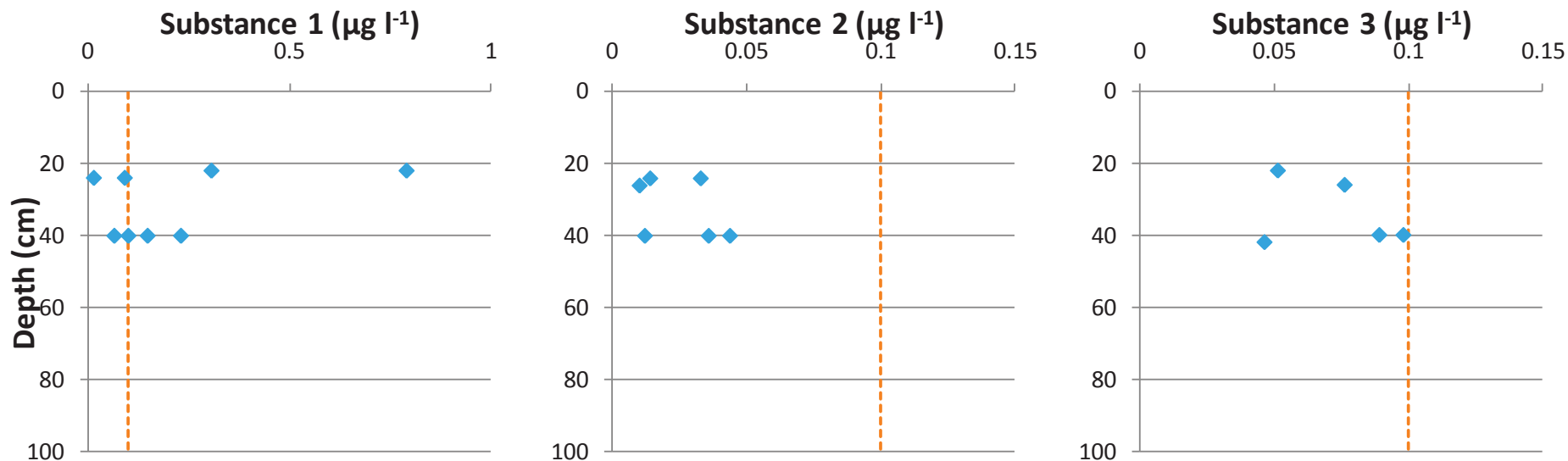
# Measurement of water fluxes

- » Rainfall event on July 14
- » Plot 1 rainfall and drop counters at 22 cm and 40 cm below surface
- » Hourly measurements shown for 44 hours



# Pesticide measurements

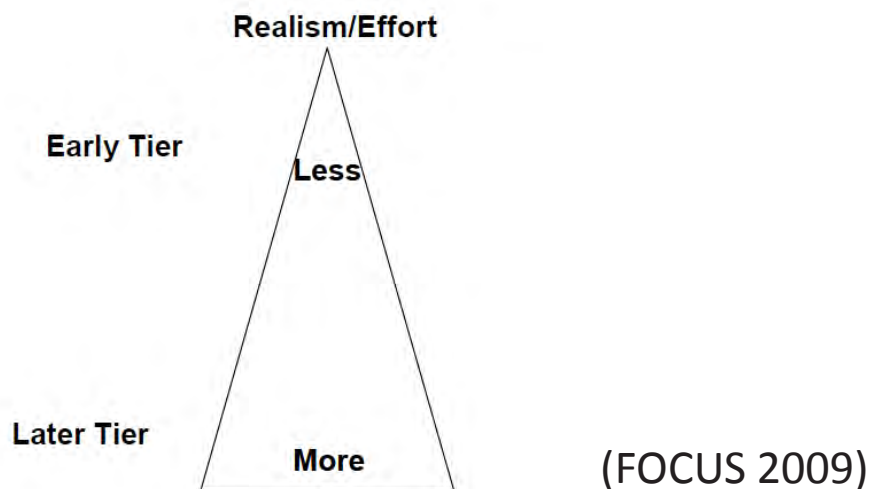
Measurements in the 3 plots at the end of the growing season, 167 days after application





# Model set-up

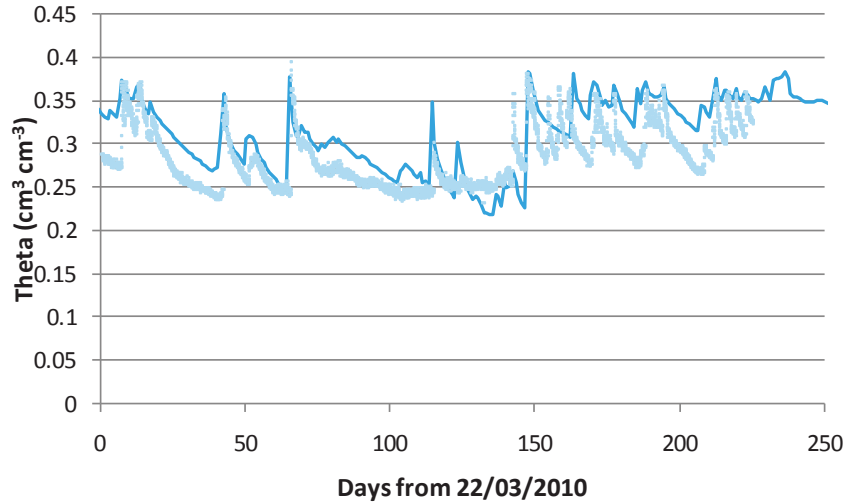
- » FOCUS guidelines: tiered approach



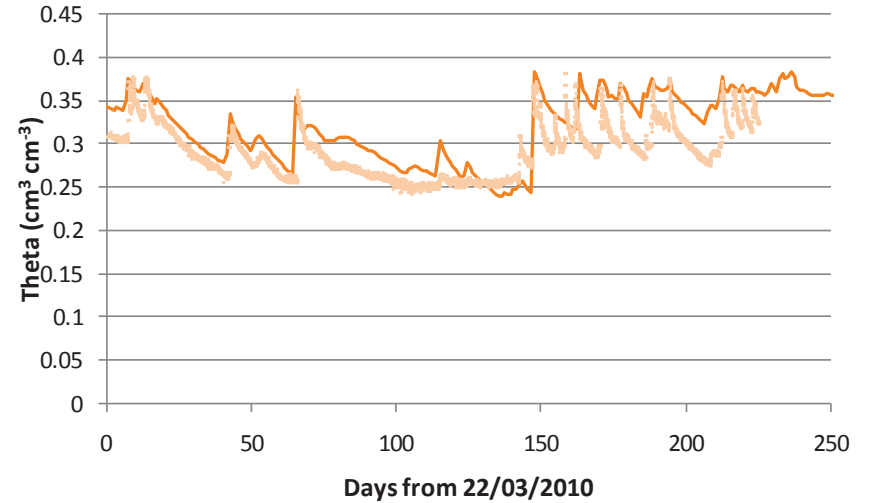
- » Simulation with FocusPEARL 4.4.4 => P90 < 0.01  $\mu\text{g l}^{-1}$
- » More detailed simulation with PEARL
  - » fallow soil; 1 year with application of 3 substances
  - » site-specific soil properties and BC

# Model results: hydrology (P2)

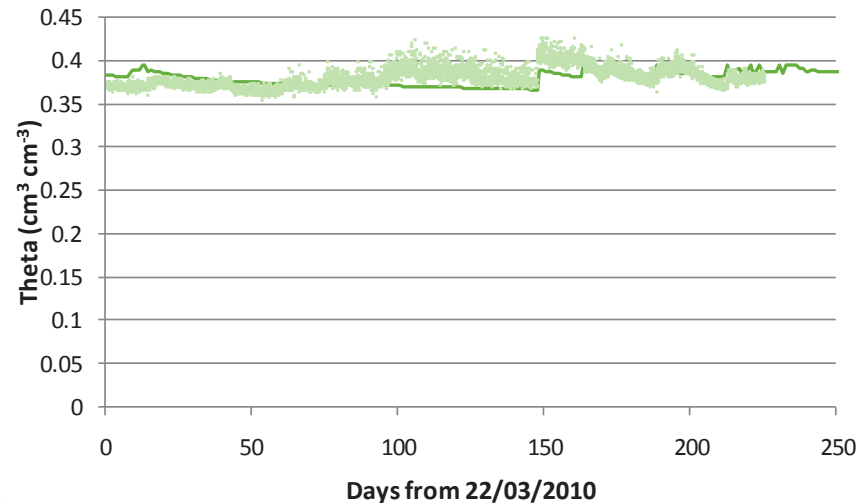
10 cm



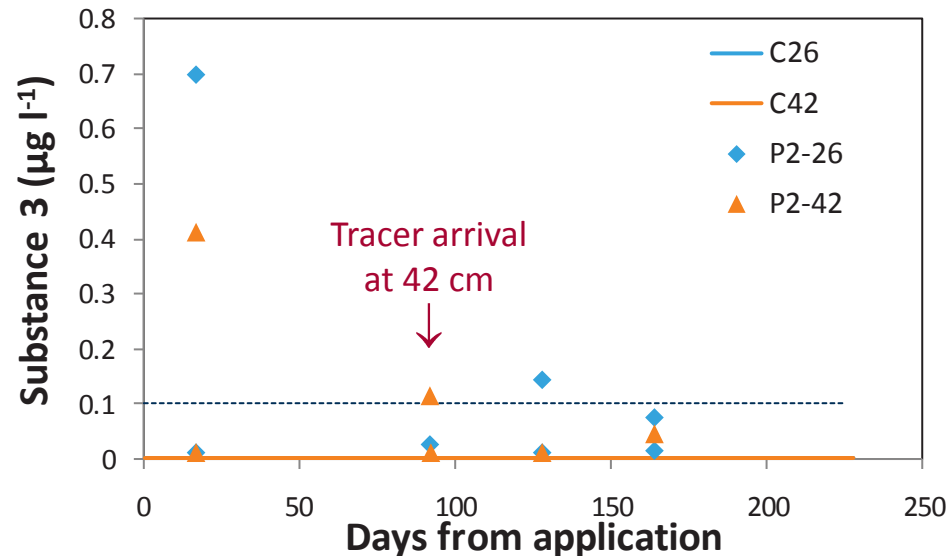
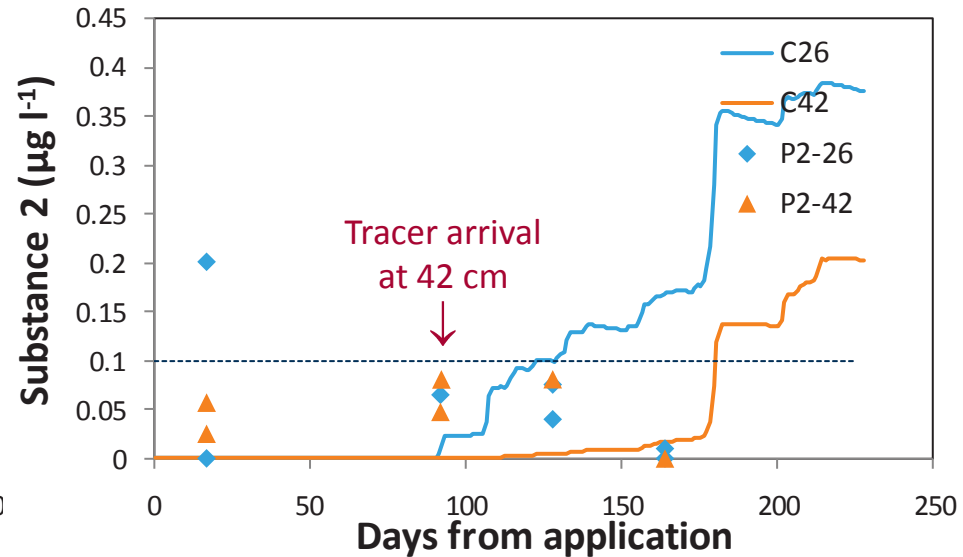
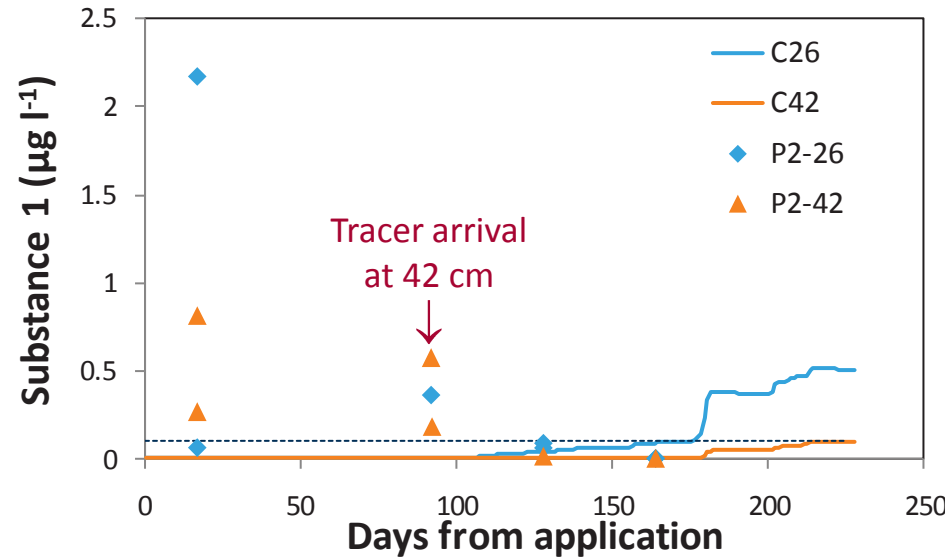
20 cm



50 cm



# Model result: pesticide concentration (P2)



Lack of agreement -> model parameters (dosage, DT50, sorption)?

⇒ (model) tracer application

Pesticide arrives earlier at 42 cm depth than tracer breakthrough

⇒ Missing process description



# Conclusion and outlook

- » Preliminary results show:
  - » preferential flow processes responsible for rapid transport of pesticides in the soil profile (potentially to groundwater) in well-structured loamy soils
  - » tiered approach (with conservative risk estimation in first tier) can give false sense of security if certain processes are not included in model set-up
- » Further steps: application of macropore flow model