

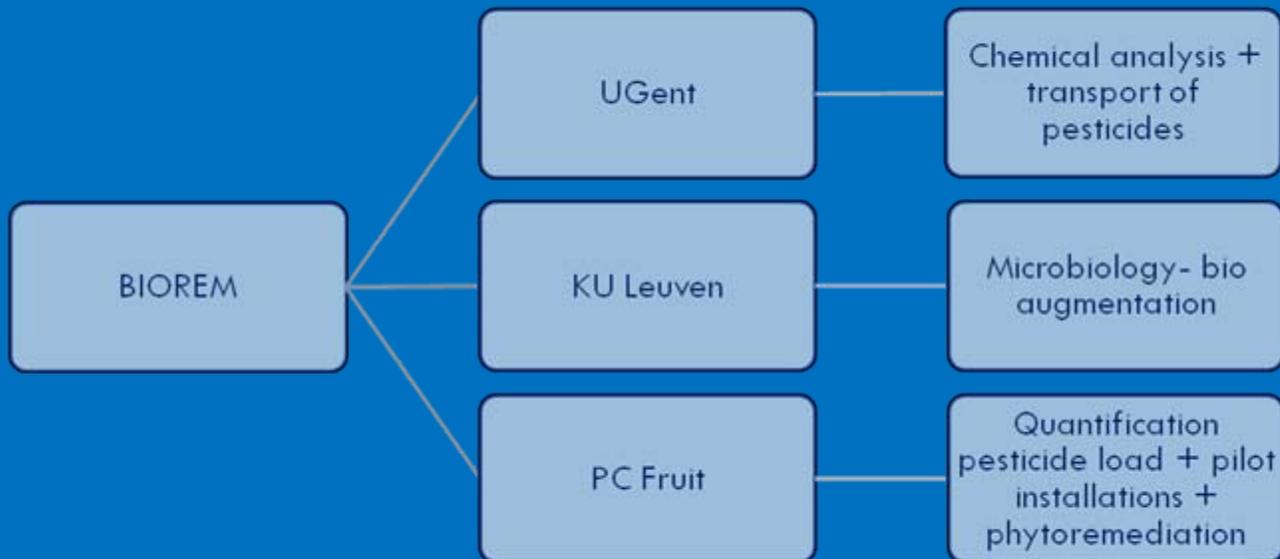
# Behaviour of pesticides in a biopurification system: Sorption and transport

Tineke DE WILDE

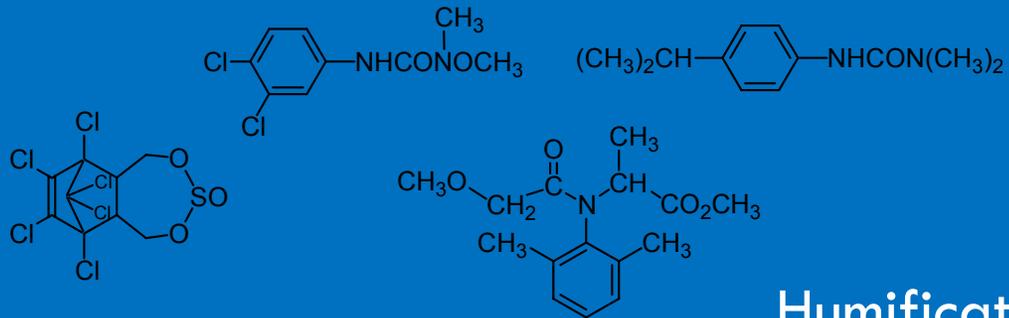


# Introduction

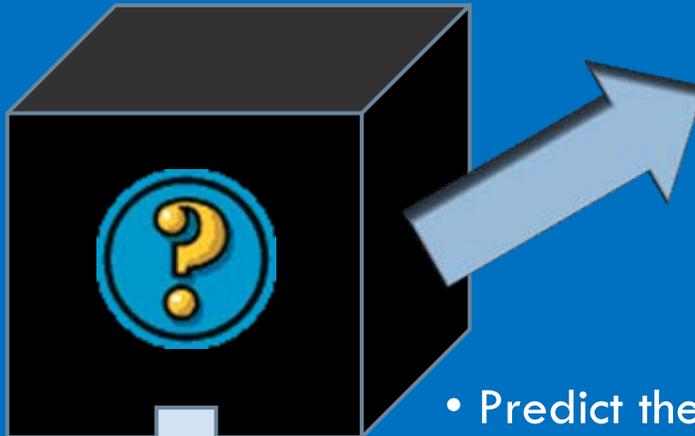
- ♦ BIOREM project: funded by IWT (Flemish government)



# Black box



Humification, sorption,  
degradation, mineralization ??



- Predict the behaviour of pesticides in the system
- Optimization of the system based on the knowledge of the molecule and the quantity of water
- Knowledge about the risks involved

# Reference pesticides



# Substrates

## Criteria

- ◆ Availability
- ◆ Price
- ◆ Nutrient content
- ◆ OM
- ◆ C/N
- ◆ pH
- ◆ EC



Coconut chips



Sandy loam soil



Dried cow manure



Willow branches



Green waste  
compost



Straw



Peat mix

# Modelling of the behaviour of pesticides

- ♦ **HYDRUS-1D** = for analysis of water flow and solute transport
- ♦ Miscible displacement of a solute in solutions is simulated by the **convection dispersion equation (CDE)**

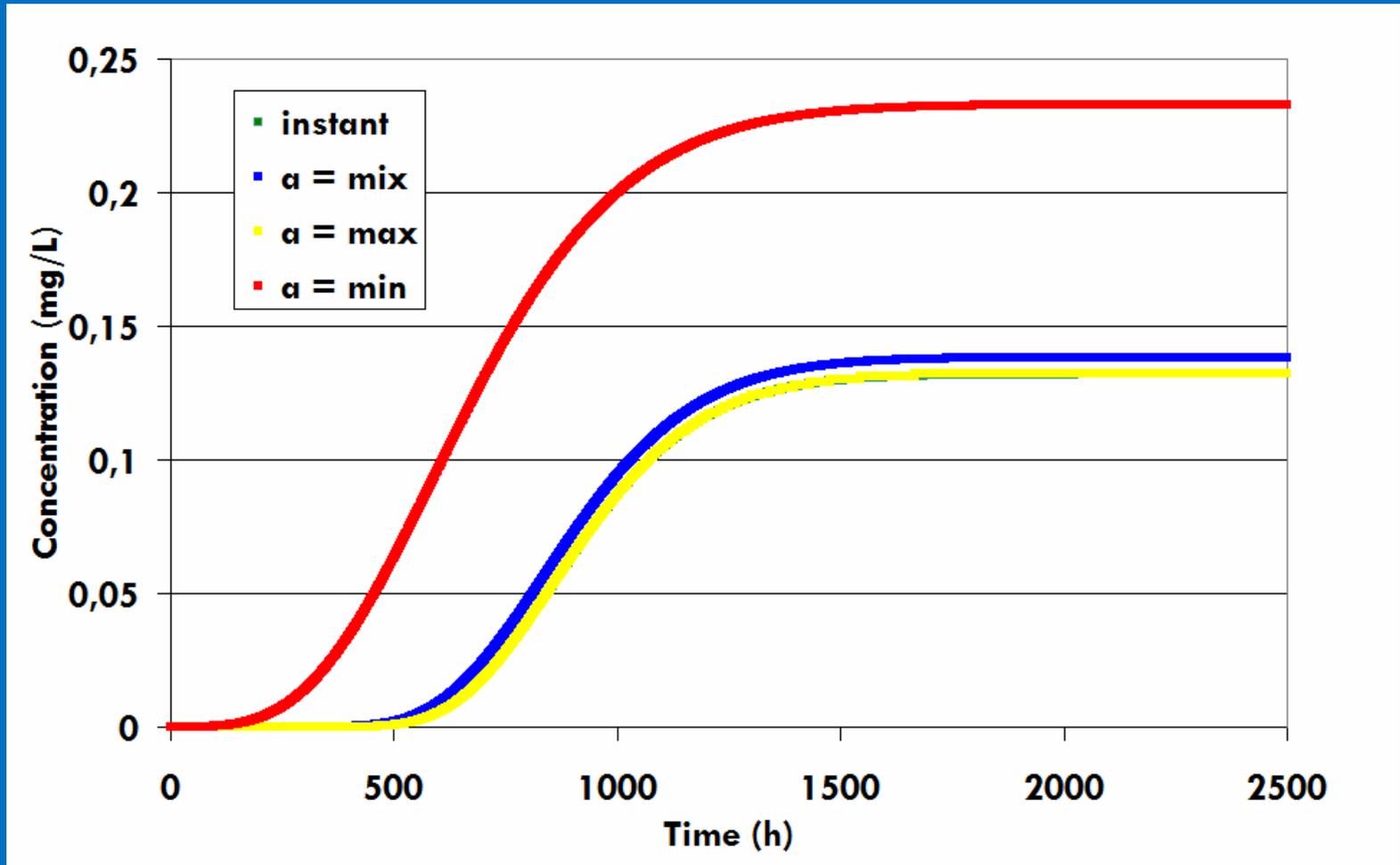
$$R \frac{\partial c}{\partial t} = D \frac{\partial^2 c}{\partial z^2} - v \frac{\partial c}{\partial z} - \mu_w c - \mu_s s$$

- $R=1+\rho/\theta.K_d$  (R: retardation coefficient)
  - $\rho$ : bulk density (kg/l)
  - $\theta$ : volumetric moisture content
  - $K_d$ : **solid-liquid distribution coefficient** (l/kg);  $K_d=s/c$
- $v$ : pore water velocity (cm/d)
- $D$ : dispersion coefficient (cm<sup>2</sup>/d)
- $\mu_w, \mu_s$ : degradation constants (d<sup>-1</sup>) in liquid and solid phase

# Sorption: kinetics - rate constant $\alpha$ ( $\text{h}^{-1}$ )

Substrate	Lenacil	Isoproturon	Metalaxyl	Isoxaben	Linuron
Coconut chips	0.05	0.13	0.16	0.19	0.20
Dried cow manure	0.25	1.45	0.15	0.32	9.69
Garden waste compost	0.56	1.18	1.16	0.56	8.28
Peat mix OM	0.70	1.04	2.35	0.70	9.07
Sandy loam soil OM	0.39	0.94	0.79	0.15	10.8
Straw	0.02	1.38	0.29	0.06	0.75
Willow chopping	0.14	0.72	0.21	0.14	8.07

# Sorption: kinetics - influence on BTC



# Sorption: sorption coefficient $K_d$

$C_{ini} = 10 \text{ mg/L}$

Substraat	Metalaxyl	Isoproturon	Linuron	Lenacil	Isoxaben	Bentazon
Coco chips	21,59ab <sup>a</sup>	10,39ab	47,32ab	53.19bc	32.30ab	0,001a
Garden waste compost	12,36ab	33,20b	203,35d	15.40ab	14.72ab	0,992a
Sandy loam soil	4,65a	0,21a	3,32a	4.16a	15.79b	0,167a
Cow manure	12,21a	59,65c	92,06d	16.73ab	5.87a	1,095a
Peat mix	48,49b	60,01b	396,55c	47.78b	40.67b	1,438a
Straw	8,82a	11,95a	189,56a	17.39a	141.59a	0,332a
Willow chopping	0,43a	14,67a	29,22a	13.20a	18.65a	0,403a

<sup>a</sup> significant letters indicate significant differences between substrates ( $p < 0,05$ )

# Sorption: correlation with substrate characteristics

	Metalaxyl	Isoproturon	Linuron	Isoxaben	Bentazon	Lenacil
<b>pH</b>	0.15	0.09	0.09	0.01	-0.02	0.05
<b>OC</b>	0.25*	0.65*	0.42*	0.32*	0.31*	0.31*
<b>EC</b>	0.22	0.14	-0.14	-0.14	-0.02	-0.13
<b>P<sub>2</sub>O<sub>5</sub></b>	0.23	0.09	-0.08	-0.08	-0.00	-0.15
<b>K<sub>2</sub>O</b>	0.18	0.15	-0.10	-0.17	-0.07	-0.07
<b>CaO</b>	0.21	0.64*	0.44*	0.37*	0.31*	0.35*
<b>MgO</b>	0.24	0.11	-0.04	-0.03	0.03	-0.11
<b>Na</b>	0.22	0.25	-0.06	-0.10	-0.02	0.00
<b>N</b>	0.28*	0.64*	0.43*	0.35*	0.31*	0.31
<b>CEC</b>	0.32*	0.75*	0.43*	0.35*	0.31*	0.35*

# Sorption: conclusion

## Substrate

Peat mix

Coco chips

Straw

Garden waste compost

Cow manure

Willow chopping

Sandy loam soil

## Pesticide

Isoxaben

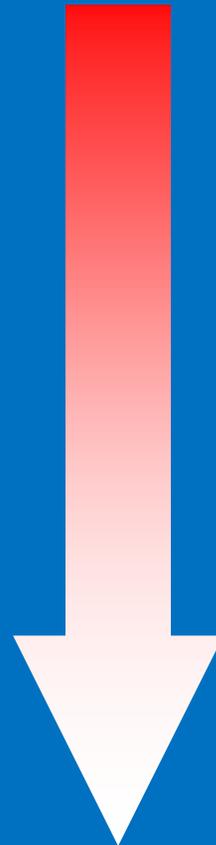
Linuron

Lenacil

Isoproturon

Metalaxyl

Bentazon



# Column experiments

25 % sandy loam soil

1

25 % peat mix

50 % straw

25 % sandy loam soil

2

25 % compost

50 % straw

25 % sandy loam soil

3

20 % peat mix

5 % cow manure

50 % straw

25 % coco chips

4

25 % sandy loam soil

25 % peat mix

25 % straw

25 % coco chips

5

25 % sandy loam soil

5 % cow manure

20 % peat mix

25 % straw

# Column experiments – set-up

1. Flow 5.1 cm/d ~ Biofilter (1 m<sup>3</sup>) = 334 l/d

→ Pesticides: metalaxyl, bentazon, linuron, isoproturon, lenacil en isoxaben

→ Abiotic columns: NaN<sub>3</sub> added

→ Inert tracer Br<sup>-</sup> added as a step input

→ Concentration: 10 mg/l

2. Flow 1.74 cm/d ~ Biofilter (1 m<sup>3</sup>) = 114 l/d

→ Pesticides: metalaxyl, bentazon, linuron, isoproturon

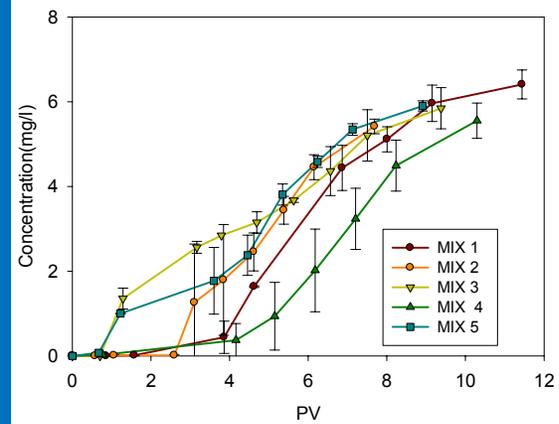
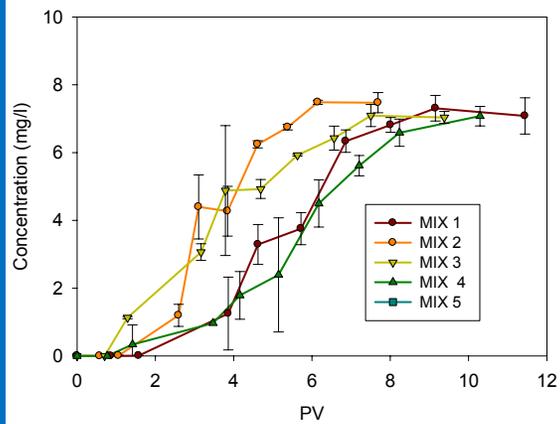
→ Inerte tracer Br<sup>-</sup> toegevoegd als puls

→ Concentration: 10 mg/l

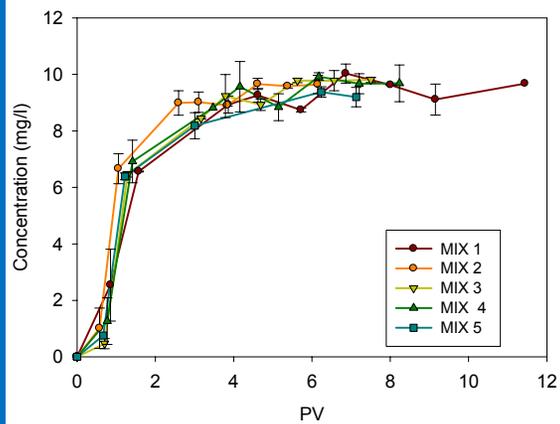


Flow =  
5,1 cm/d

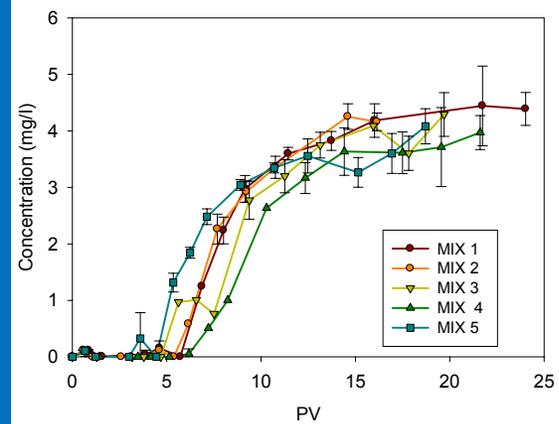
Metalaxyl



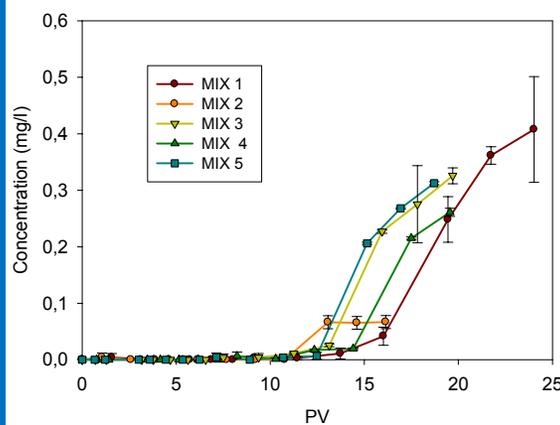
Isoproturon



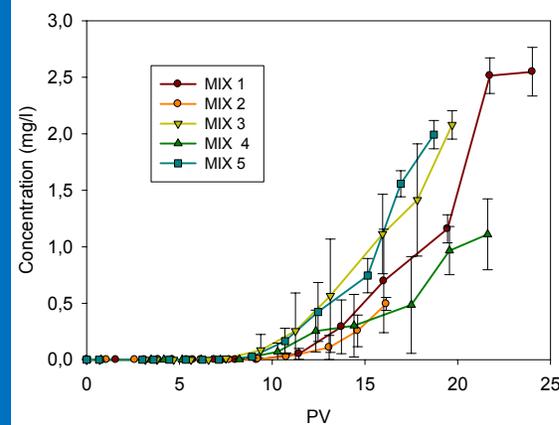
Bentazon



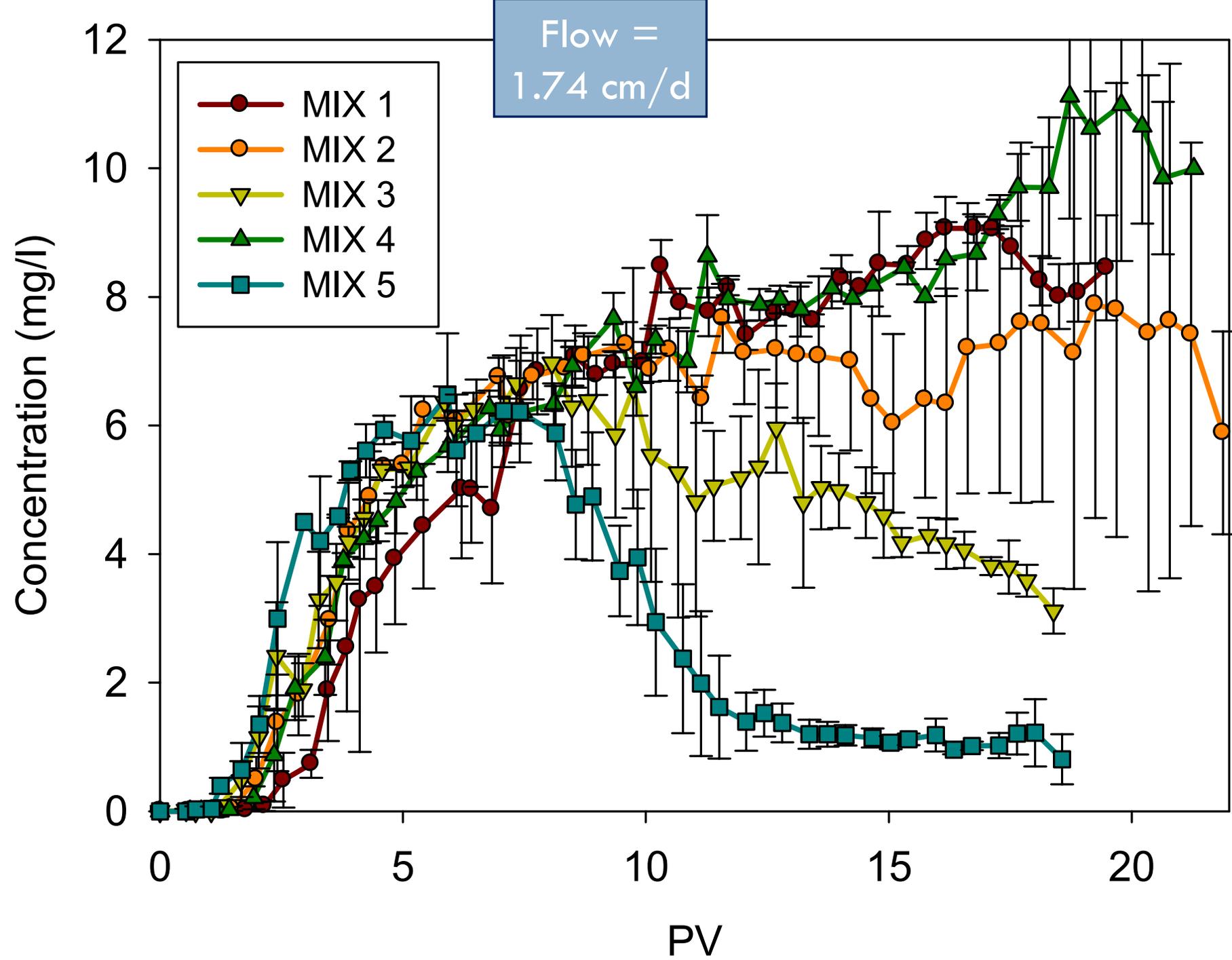
Lenacil



Isoxaben



Linuron



# Conclusion column experiments

- Mobility ( $K_{oc}$ ) is a good indicator for the leaching through a column
- Leaching potential: bentazon > isoproturon  $\approx$  metalaxyl > linuron
- **Composition of the matrix** has a limited influence on leaching
- Addition of **cow manure** could increase degradation ?
- Higher flow  $\rightarrow$  faster leaching
- Determination sorption coefficient by batch experiments  $\rightarrow$  **overestimation**
- **Future experiments:** pesticides with similar physico-chemical characteristics, columns with soil inoculated with pesticide degrading microorganisms.

# Upscaling



# Thank you for your attention!!

