Effect of three hydrodynamic parameters on the transfer of four pesticides in an experimental flume

Cemagreg

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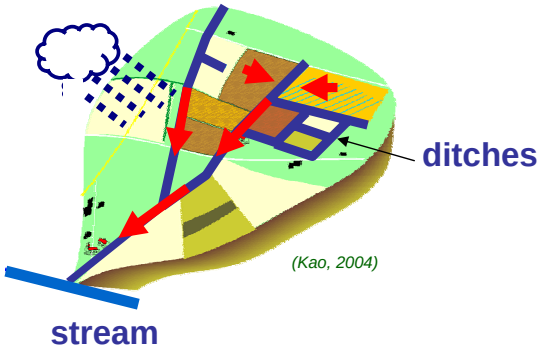
Context and general objectives

- Buffer strips are promoted to reduce pesticide transfer by runoff to water courses
- But their efficiency is compromised by the presence of concentrated flow
- Farm ditches are widespread systems in rural landscapes
- They constitute direct hydraulic connections between fields and stream



- **General objectives of this work**:
  - to improve knowledge on pesticide potential retention in farm ditches
  - to provide basic information for diagnosis and risk mitigation through best management of these systems

Problematic and specific objectives

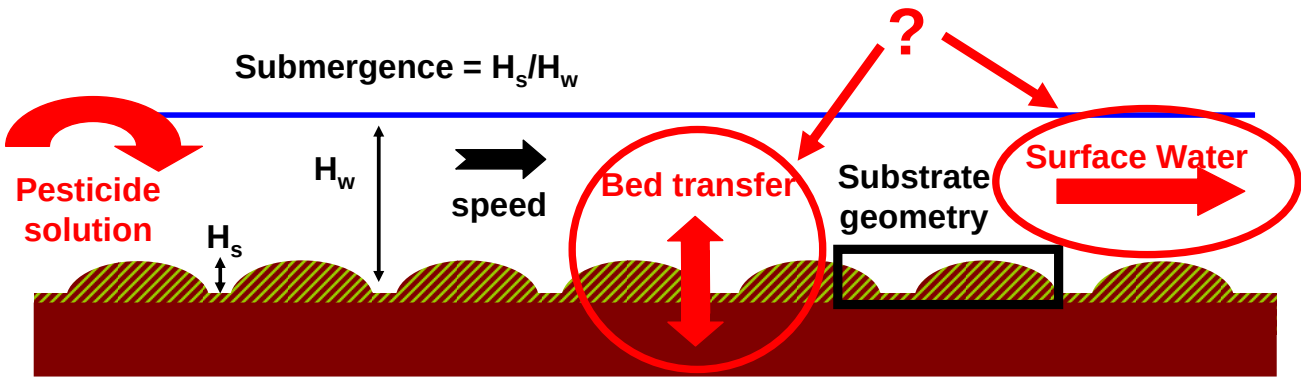
Brief state of the art:

- A **mitigation of pesticide transfer in ditches** has been highlighted in link with the presence of **bed sediment or vegetation**
- **Adsorption on vegetation** appears more important for short time steps
- **hydraulic parameters** greatly influence **surfaces of interaction and contact time** but results are **contradictory**

Specific objective and approach of this work:

- Evaluate the influence on **pesticide transfer :**
  - **of 3 hydraulic parameters** highlighted as influent in the literature for other solute transfer (as heavy metals, dyes, surfactants)
  - **in presence of an organic well defined substrate material**
  - **in controlled conditions via an experimental flume**

Studied parameters



- **Studied Parameters and range of variation:**

water speed: 1.5 - 7.6 cm/s
submergence: low - high
substrate geometry: small dunes, high crenels

Studied pesticides

Name	Classification	Water solubility mg.L^{-1}	Koc (L.kg^{-1})	DT 50 (d)
Diuron (DIU)	Herbicide	36	480	90-180
Isoproturon (IPU)	Herbicide	70	120	6-28
Tebuconazole (TBZ)	Fungicide	36	1554	43-170
Azoxystrobin (AZS)	Fungicide	7	423	9 - 14

- **A range of physico-chemical characteristics**
- **Analysis characteristics (Laboratoire d'analyses du Cemagref Lyon):**
  - Pesticides : direct injection in LCMSMS (LoQ : 0,02 to 0,2 µg/L)
  - Bromide : ionic chromatography (LoQ : 0,18 mg/L)

Studied substrate

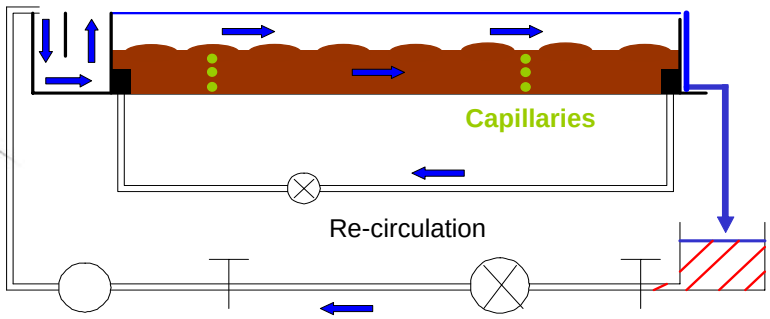
- **Natural ditch substrate are various, heterogeneous and variable with time:**

  Sediment, grass, dead leaves …

→ **Choice of hemp fibres as a standard**

  - composition and structure stable with time and space
  - made of natural fibres (mainly cellulose)
  - porosity : 0.38 ; hydraulic conductivity: 3.1 cm.s^{-1}

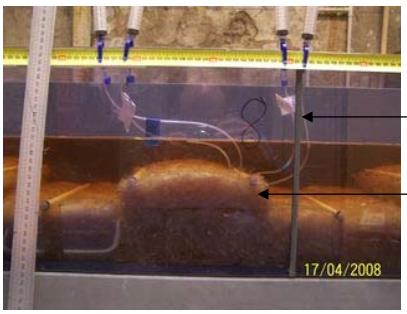
Experiment implementation



Studied variables :

- solute concentrations
  - in surface water
  - in the substrate

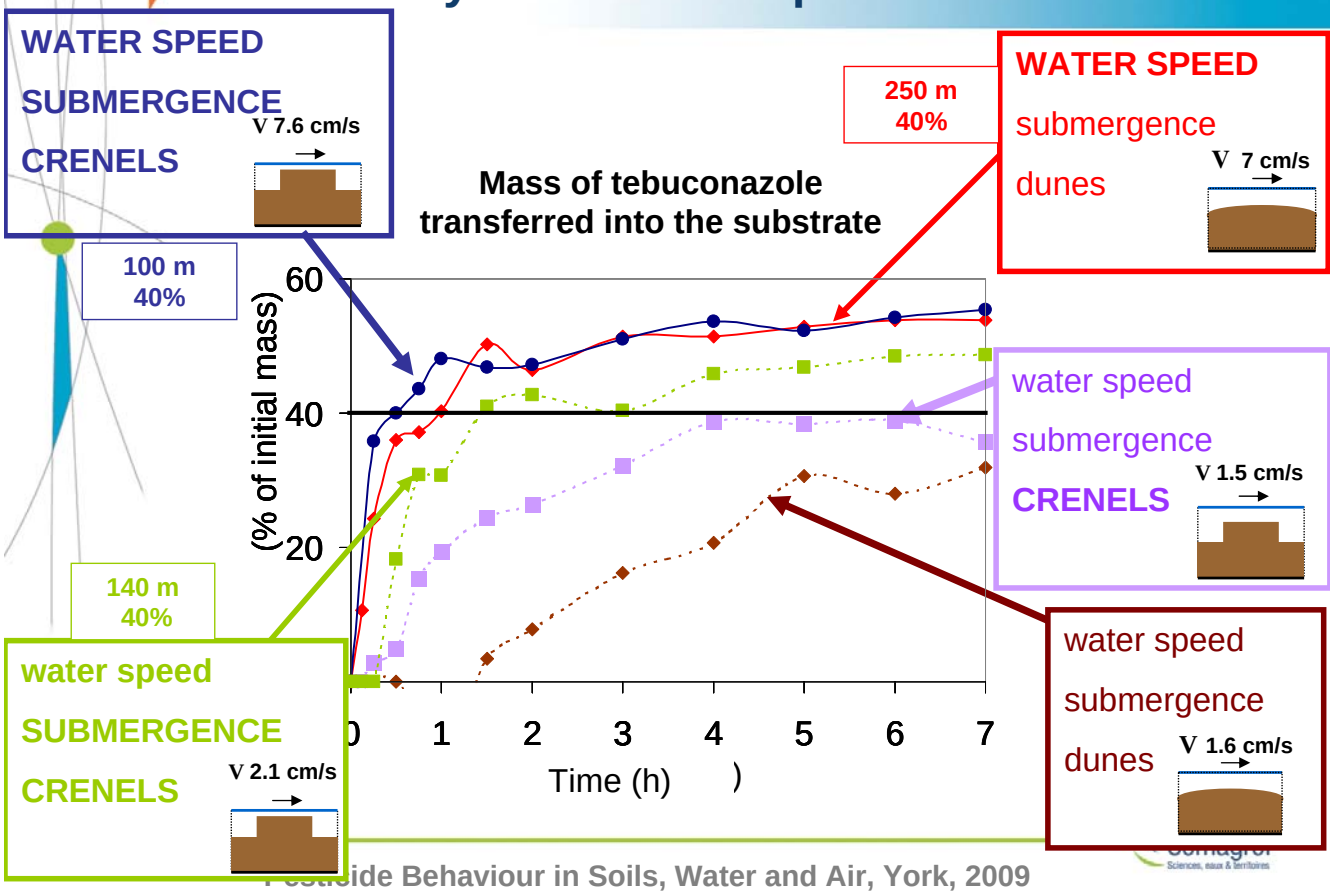
The flume outlet



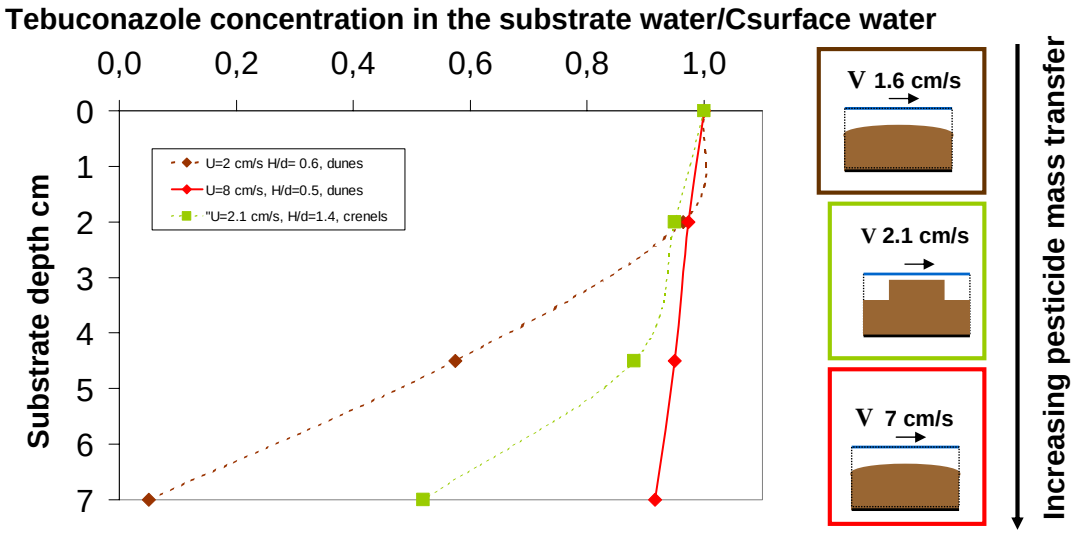
a capillary and sampling syringe

a crenel

Global analysis of studied parameters influence



Influence on the depth of tebuconazole transfer into the substrate after 7h



a water speed increase or a submergence increase/crenel geometry increases:

- the depth of pesticide transfer into the substrate
- the potential substrate compartment available for retention and adsorption

Results according to the pesticide

Characteristic values after 7h	IPU	DIU	AZS	TBZ
Mass transferred into the substrate (% of initial mass)	11 - 45	26 - 48	24 - 59	32 - 55
Adsorption (% of initial mass)	0 - 10	9 - 12	7 - 27	14 - 21
Kd on hemp (batch) L/kg	3	13	22	34
Standard Koc (literature) L/kg	*120*	*480*	*423*	*1554*

Adsorption capacity is coherent with the Kd values on hemp

Comparison with field experiments

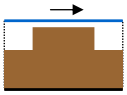
Field data from Margoum 2003 : runoff simulations with a pesticide and tracer solution in ditches. *La Jaillière experimental farm, Arvalis Institut du Végétal, France*

1. CETRAIS

deep layer of dead plants and leaves (10 cm)

Water speed = 3 cm/s
Water height = 15 cm
Water flow = 2,5 L/s

V 2.1 cm/s



Percentage of pesticide dissipation on 50 m

	IPU	DFF	TBZ
Cétrais	27%	54%	-
Flume	29%	-	24%

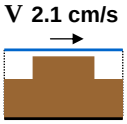
DFF : diflufenican, Koc = 1990 L/kg

2. FROUST

Downslope: plants and deep layer of dead leaves (10 cm)

Water speed = 2 cm/s
Water height = 25 cm
Water flow = 10 L/s

V 2.1 cm/s



Percentage of pesticide dissipation on 100 m

	IPU	DIU	DFF	TBZ
Froust (down slope)	34%	36%	40%	-
Flume	35%	36%	-	38%

- Both cases : Good agreement between flume and ditch experiment results with deep organic substrates (dead plants and leaves). DFF appears more dissipated than the others (higher Koc and kinetic ?)

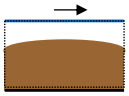
Comparison with field experiments

3. FROUST

Upslope: sediment and few plants

Water speed = 2 cm/s
Water height = 25 cm
Water flow = 10 L/s

V 1.6 cm/s



Percentage of pesticide dissipation on 100 m

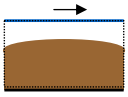
	IPU	DIU	DFF	TBZ
Froust (upslope)	0%	0%	28%	-
Flume	0%	2%	-	4%

4. CORAUX

sediment and thin deposits of dead leaves over 100 m

Water speed = 5 cm/s
Water height = 8 cm
Water flow = 2.5 L/s

V 7 cm/s



	IPU	DIU	DFF	TBZ
Coraux	0%	5%	38%	-
Flume	27%	30%	-	36%

- Case 3 : Similar very low dissipation rates for IPU and DIU (same order of magnitude for TBZ). Much higher dissipation for DFF (higher Koc and kinetic ?)
- Case 4 : Higher water speed much favourable to the dissipation of IPU and DIU in the deep hemp substrate than in the sediments. DFF still highly retained (higher Koc and kinetic ?)

Conclusions

- **For the deep porous and organic tested substrate, the mitigation by pesticide transfer into the substrate is enhanced when:**
  - the surface water speed increases,
  - the submergence increases,
  - the substrate geometry turns from small dunes to large crenels
- **The mitigation depends on the pesticide (Koc)**
- **On a management point of view ;**
  - it is likely that vegetated ditches with deep and porous organic bed material are good candidates for pesticide mitigation
  - increasing ditch length, sinuosity and bed organic content should be promoted when possible (if compatibility with the other functions ditches)

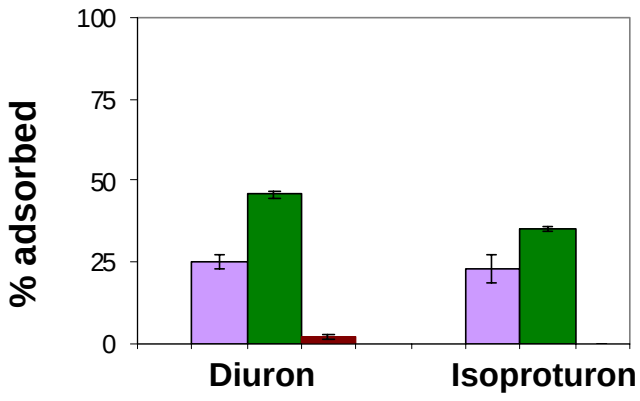
Perspectives

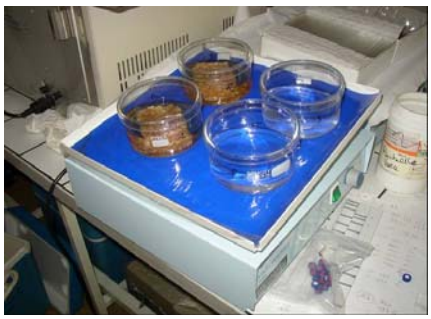
- **Conceptualise and model the observed pesticide transfer into the substrate taking into account the influence of the tested parameters**
- **Make complementary field observations so as to:**
  - consolidate the results
  - be able to propose a typology of ditches according to their potential to mitigate pesticide contamination
- **Study the fate of pesticide into the substrate (long term-adsorption, degradation, low restitution to the water column?)**

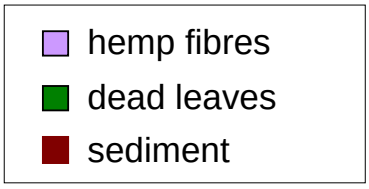
Thank you for your attention

Studied substrate

- **Comparison of diuron and isoproturon adsorption on the studied substrate with adsorption on ditch dead leaves or sediment**
  - **adsorption batches with gentle shaking over 8 h**







  - **sediment < substrate < dead leaves**
  - **adsorption kinetics on hemp and dead leaves are similar**