Stormwater infiltration, 20 years of control and regulations experiences

What have we learnt?

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National Institute of Applied Science, Lyon (France)

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

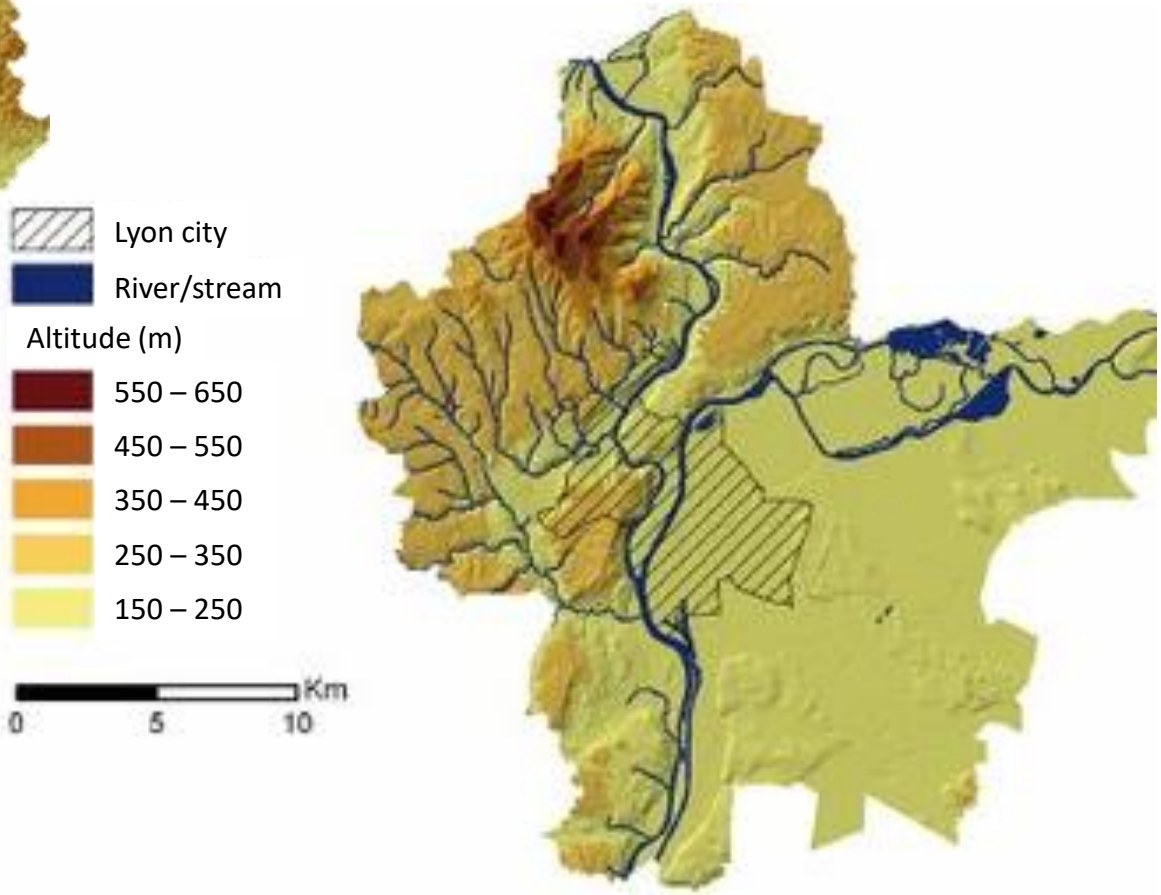
deep

A few words about me

- **Water engineer**
- **PhD in urban hydrology**
  - Laboratory on Water, Environment and Urban Systems (LEESU, Paris area)
- **Associate professor, INSA Lyon**
  - **Research**: Laboratory on Wastes, Water, Environment, Pollutions ⟶ Multidisciplinary and multi-scale research in environmental engineering
  - **Teaching**: Civil Engineering and Urban Planning Department

A few words about Lyon

- **Steep topography to the North & West**
- **Flat topography to the East, with no surface streams**

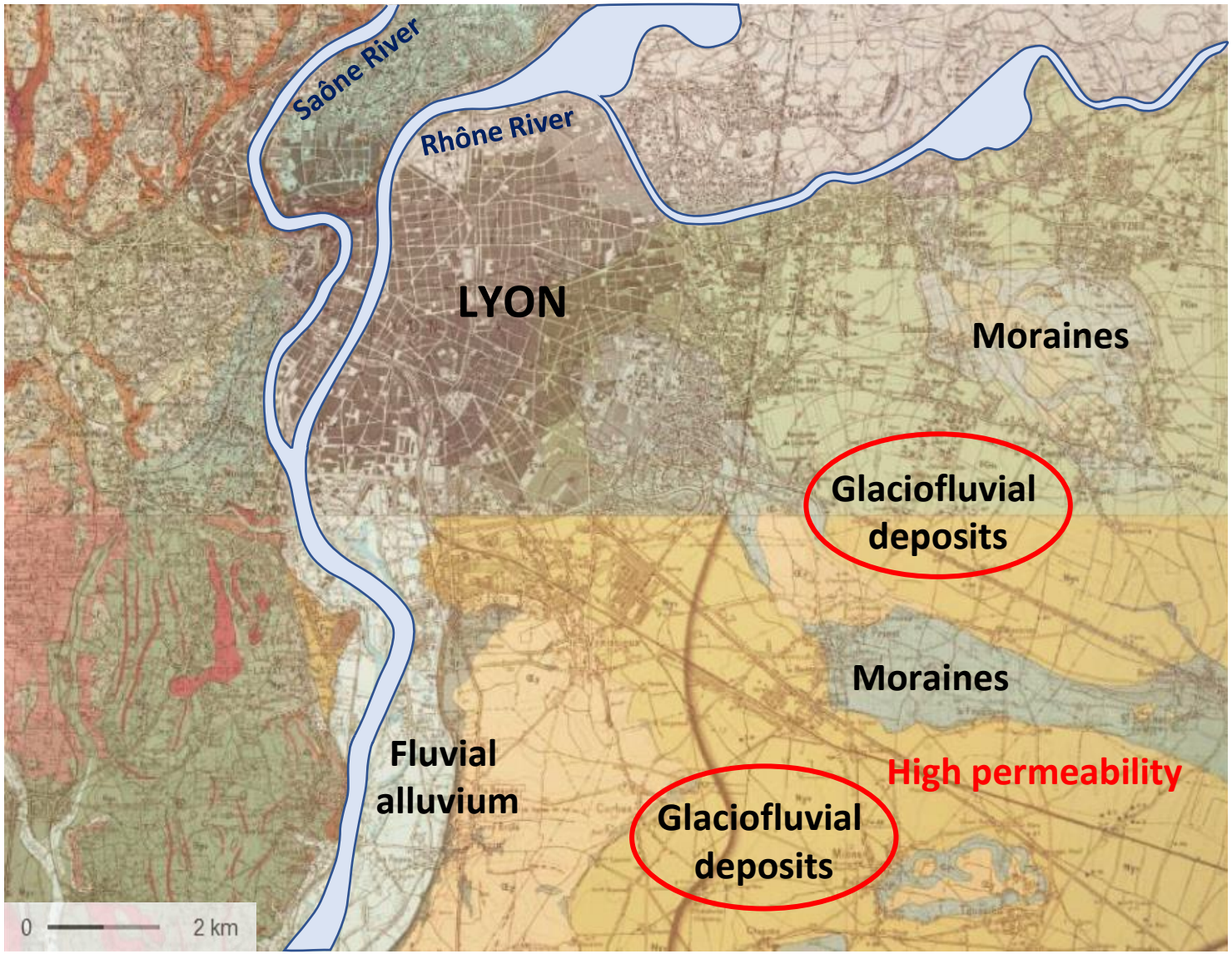


A few words about Lyon

Western Lyon

Eastern Lyon

Geology of the Lyon area



Consequences on stormwater management

- **Flat area with rising levels of impervious cover**
- **No surface outlet for storm sewers**
- **High permeability of the soil**

Wide use of infiltration systems since the 1980's

Consequences on stormwater management

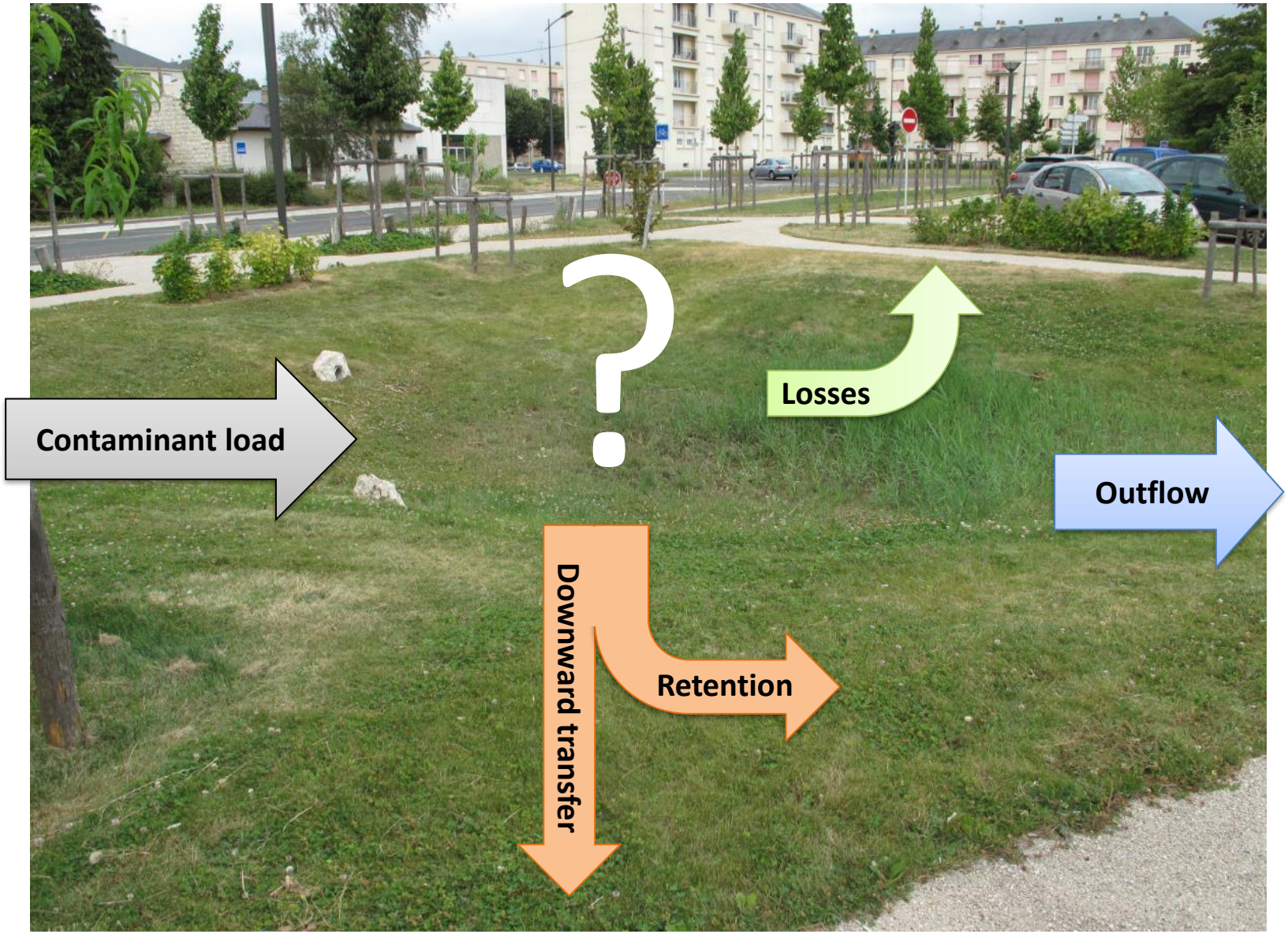
From “first-generation” centralized infiltration basins…

…to more integrated source-control devices

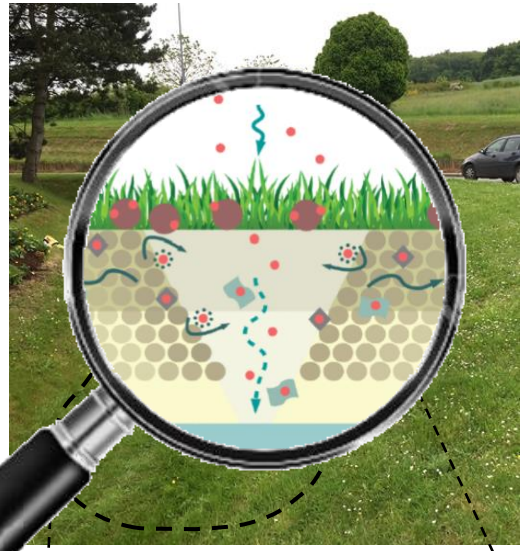
With long-term scientific survey of:

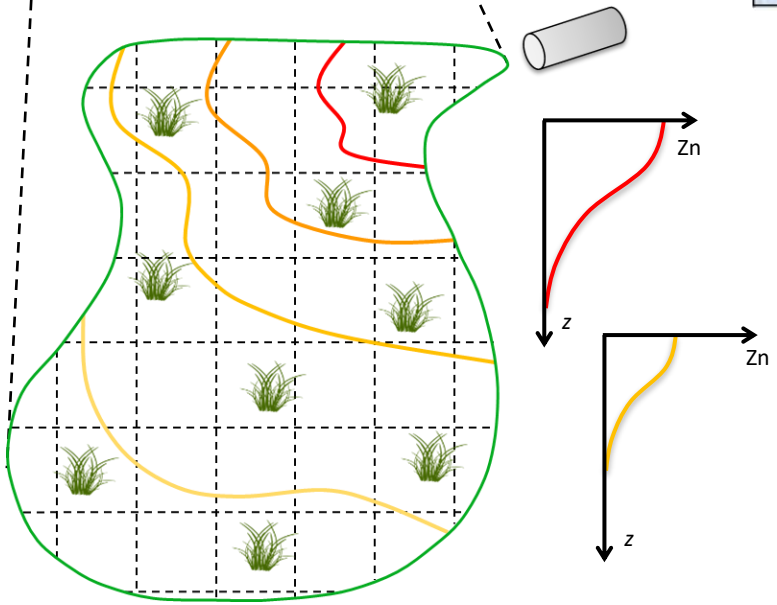
- Runoff and soil contamination
- Small- to large-scale effects of SuDS
- Possible downward transfers

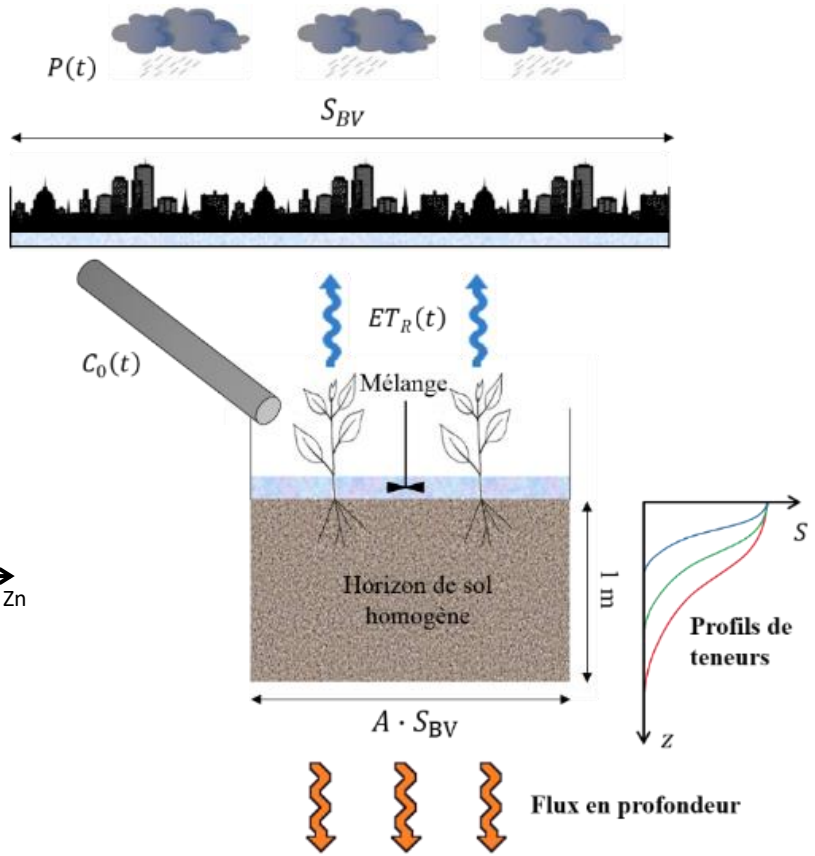
My research topic: fate of contaminants in SuDS



Combining experimental & modelling approaches



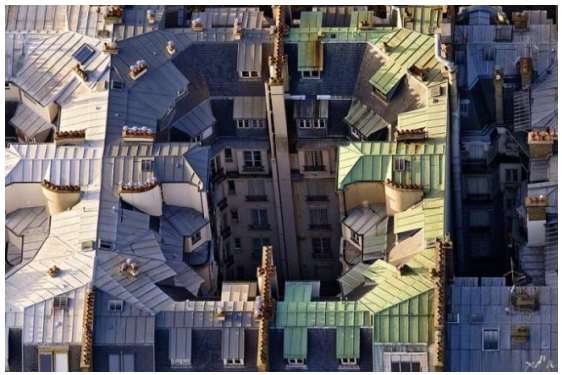




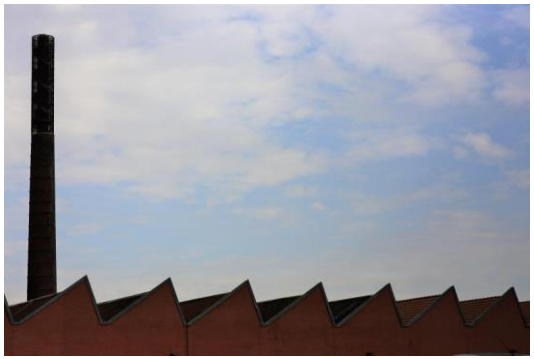
Understanding what is at stake

- **Diffuse contamination with multiple sources**
  - Land use
  - Human activities
  - Practices

} Uneasy to control

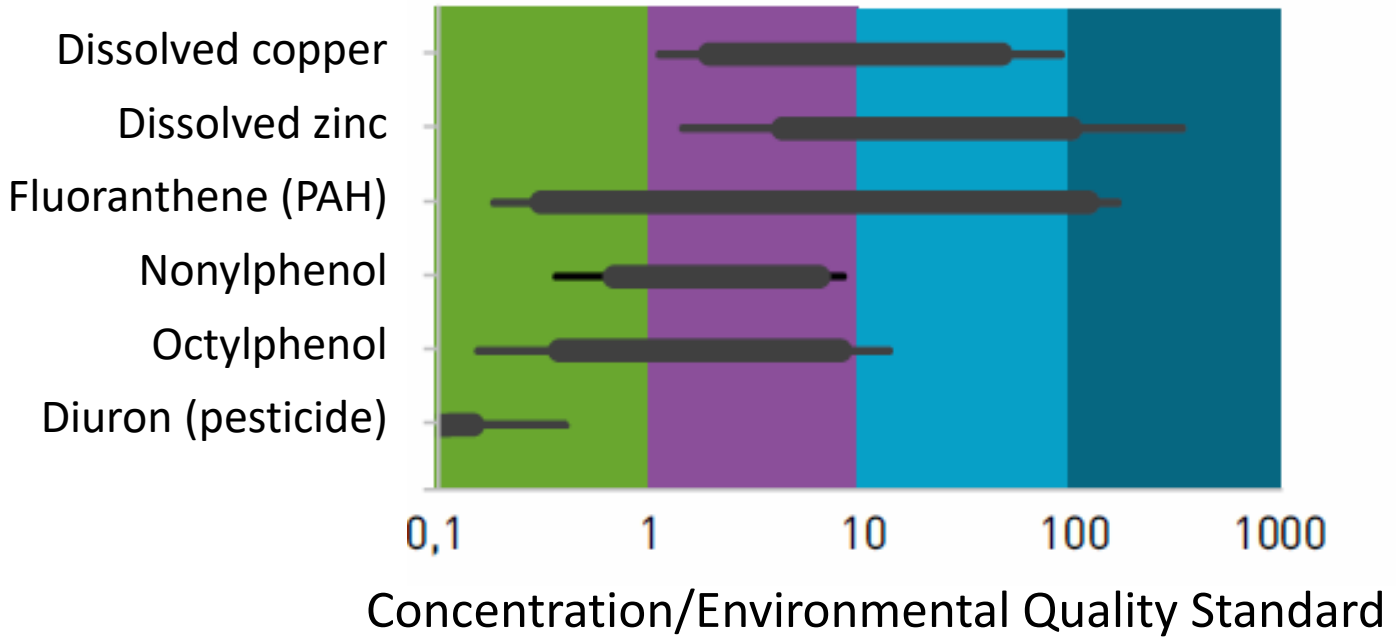







Understanding what is at stake

- **Often moderate concentrations in runoff… but still likely to impair water quality**

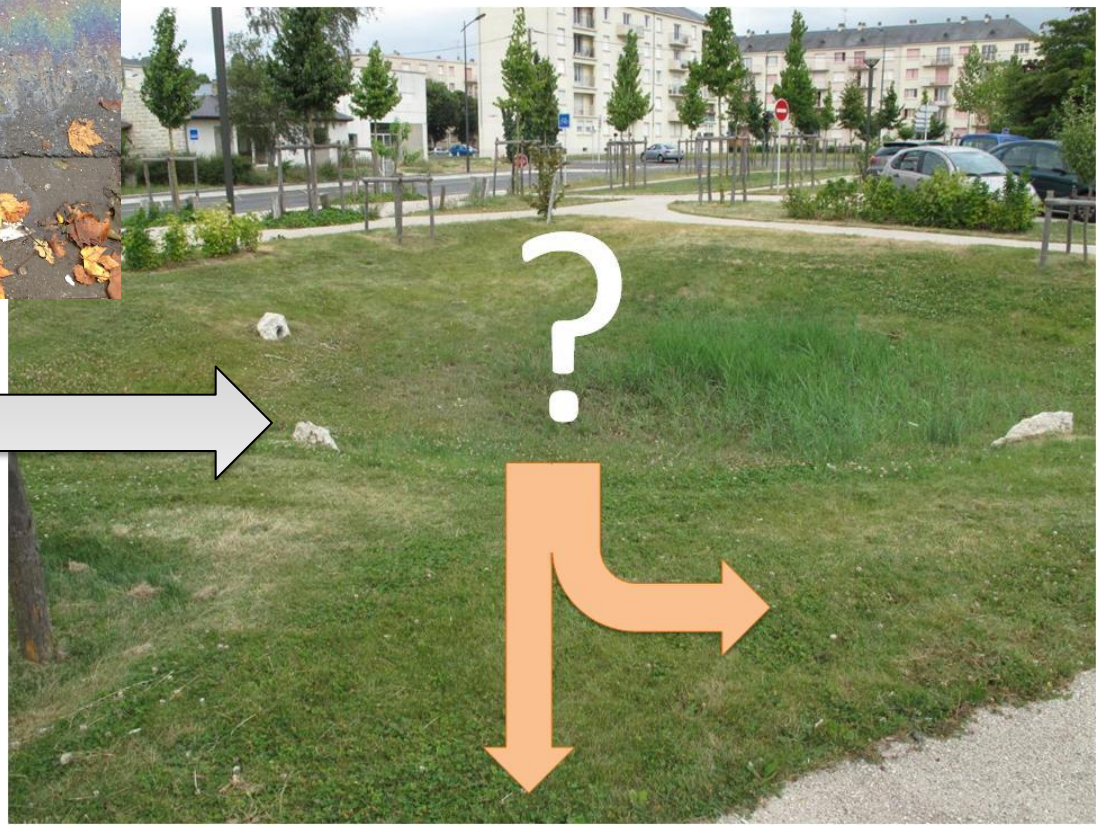


Source: research projects *Roulépur*, *Micromégas*, *Matriochkas,* 2019

- **Increasing diversity of contaminants from upstream to downstream points in the sewers**

Understanding what is at stake

- **Before looking at the impacts of infiltration on soil and groundwater…**



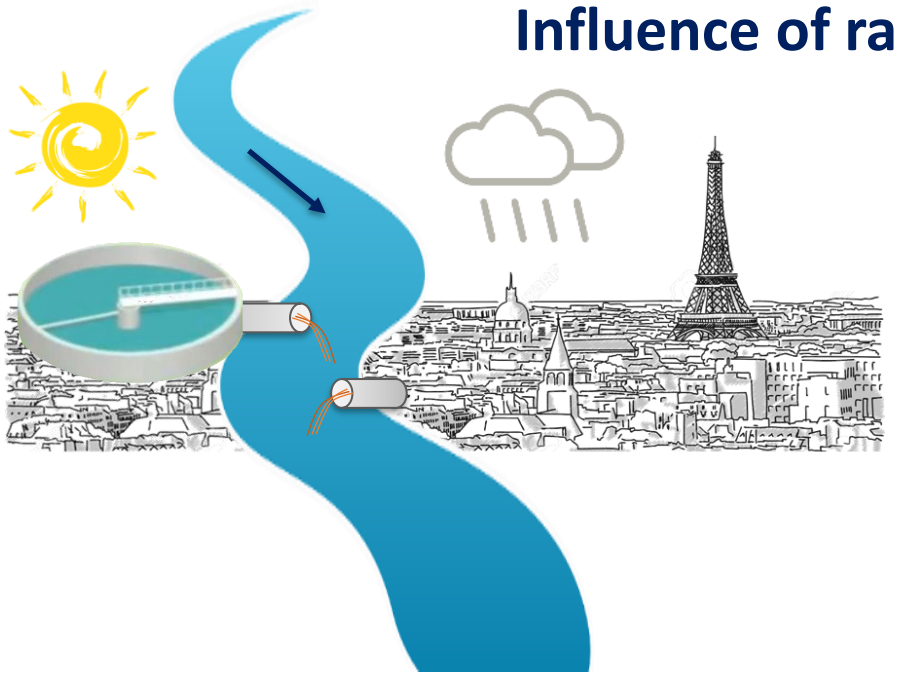
Understanding what is at stake

- **Before looking at the impacts of infiltration on soil and groundwater…**
- **…what is the alternative?**
- **…and what are the consequences?**
  - In France: increase in impervious surfaces equivalent to **160 soccer fields** each day!
  - Deficiencies of the sewer network: floods and contaminant discharges to surface waters

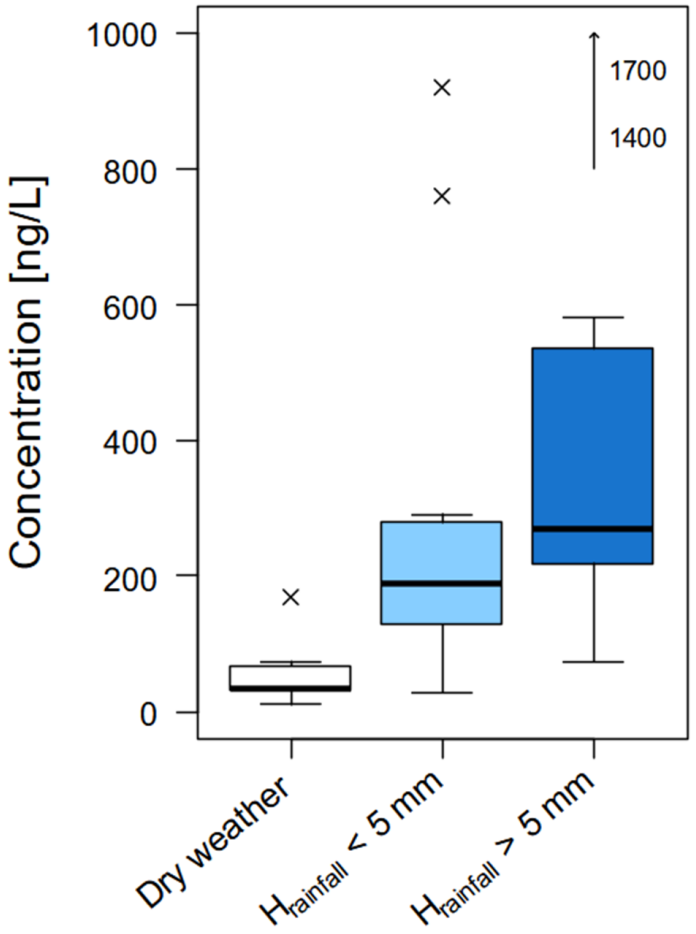
Nicolas Journoud, Méli Mélo ©Graie

An example (from Paris)

Influence of rain-induced discharges?

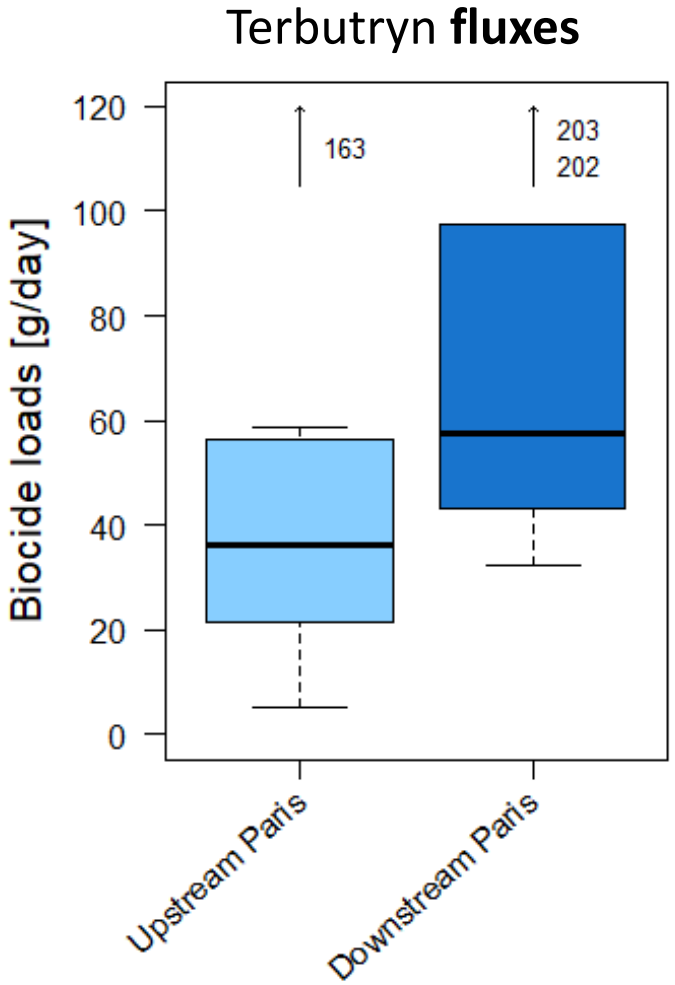


Benzalkonium **concentrations**



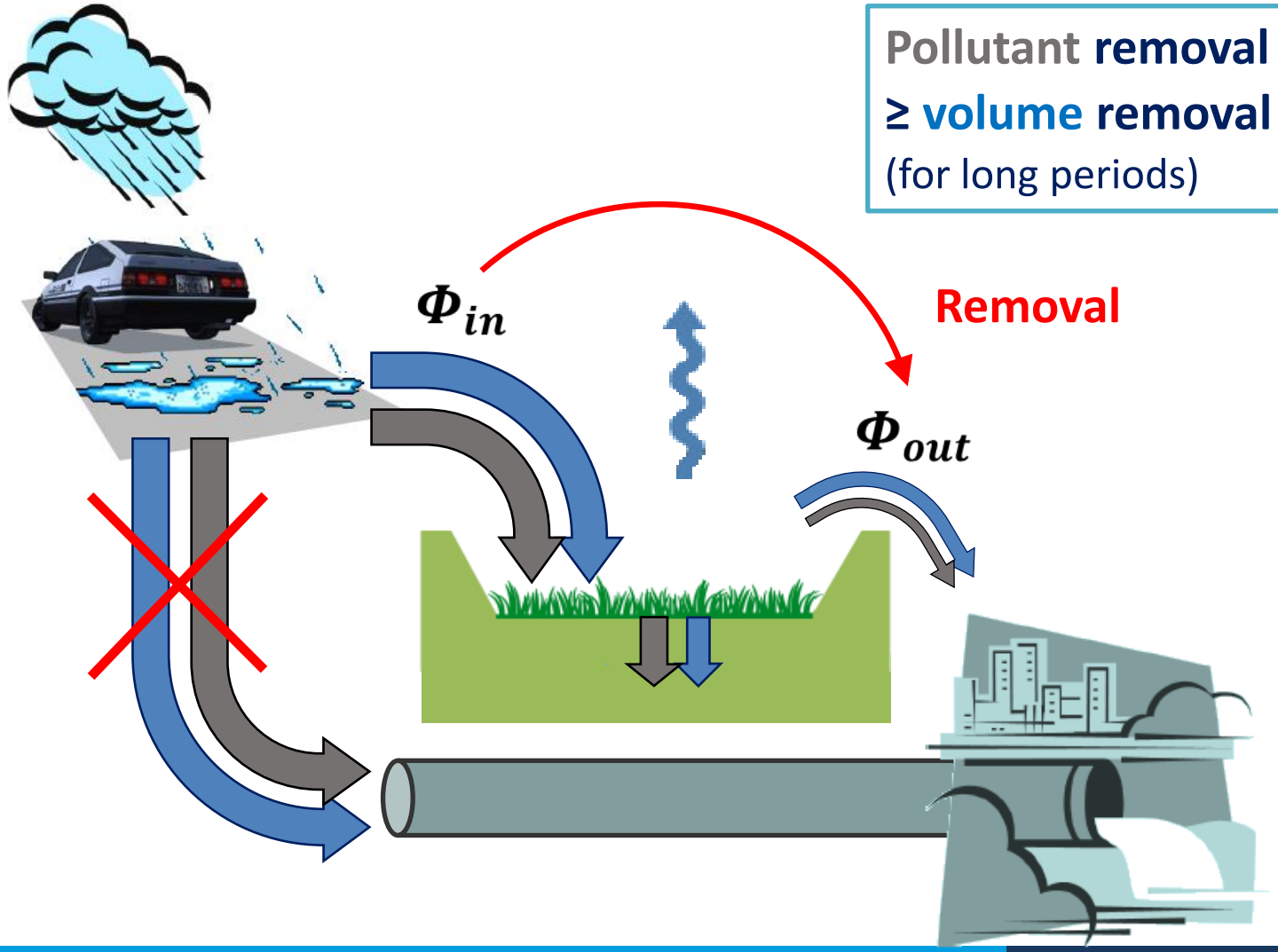
An example (from Paris)

Upstream-downstream differences?



Understanding what is at stake

- **Stormwater infiltration preserves the river quality!**



Is SuDS soil a good filter?

- **For most contaminants, yes!**
- **Filtration & infiltration are more efficient than settling**
- Inflow and outflow measurements (concentrations + volume) in 11 different systems with contrasting designs and hydraulic behaviors

(In)filtration | Settling

Source: research projects *Roulépur*, *Micromégas*, *Matriochkas,* 2019

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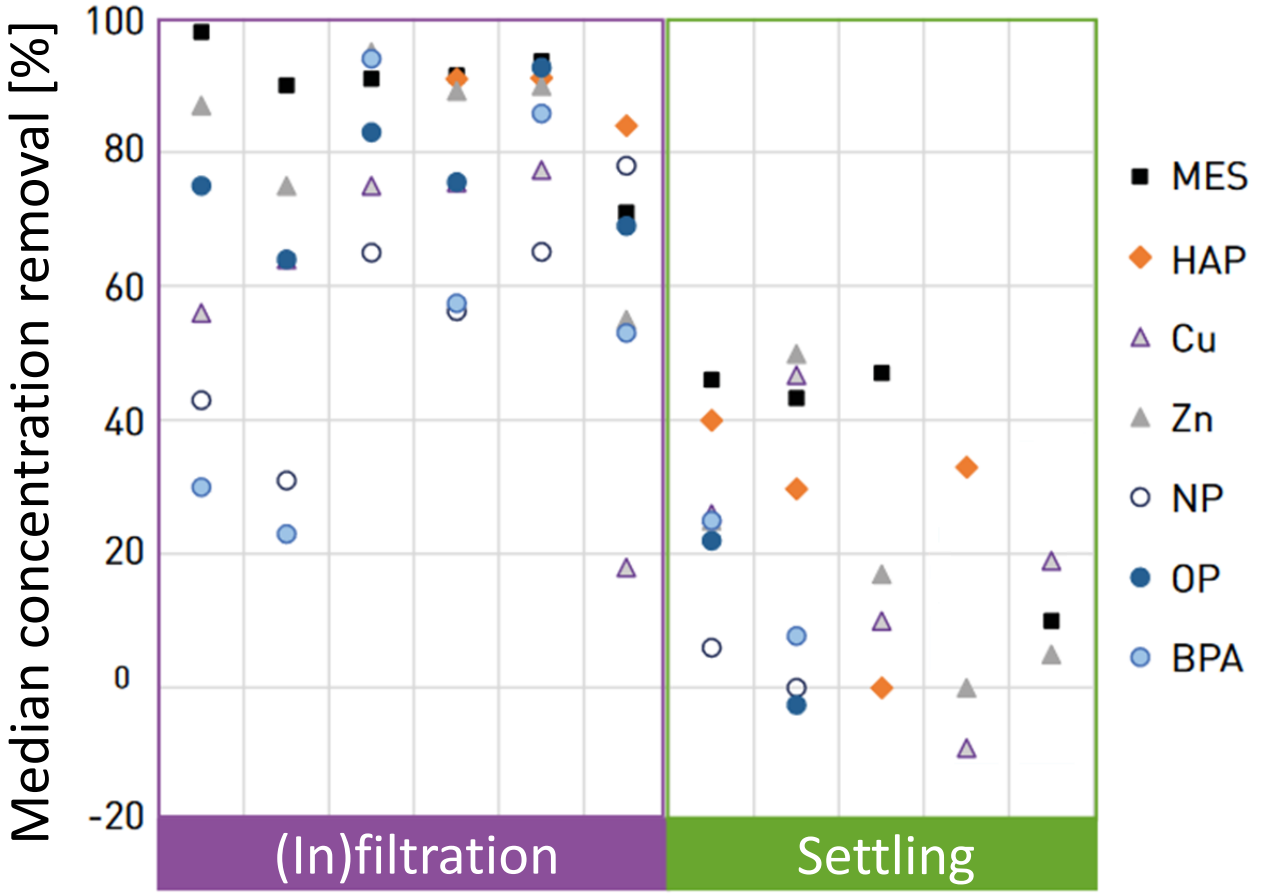

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Is SuDS soil a good filter?

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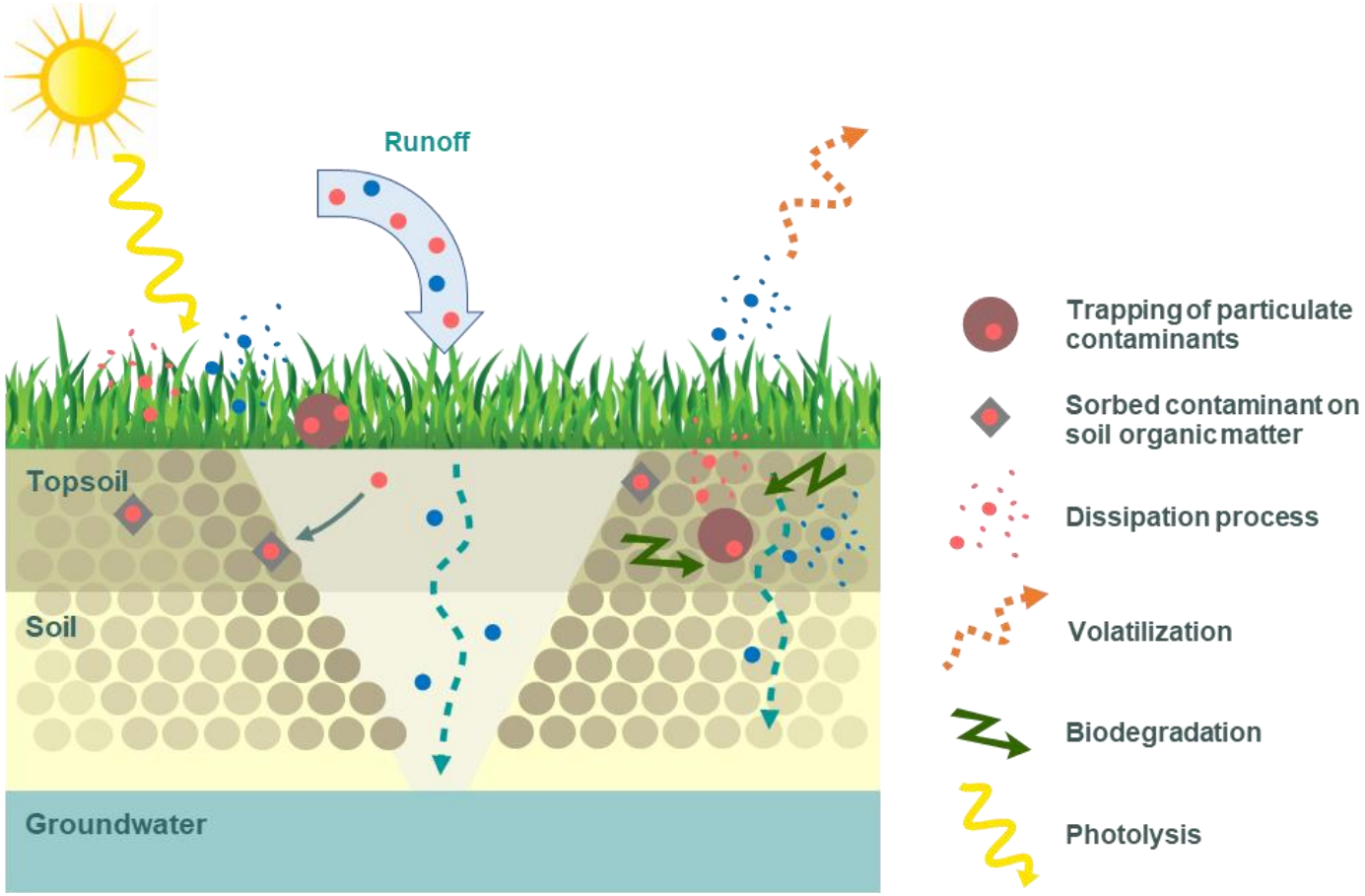
- **Organic contaminants: it is necessary to distinguish**

***hydrophobic* molecules** **and** ***hydrophilic* molecules**



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  - **…*hydrophobic* molecules** ⟹ Good retention in soil

e.g. PAHs

  - **…*hydrophilic* molecules** ⟹ Likely to be transferred

e.g. pesticides, biocides, BPA

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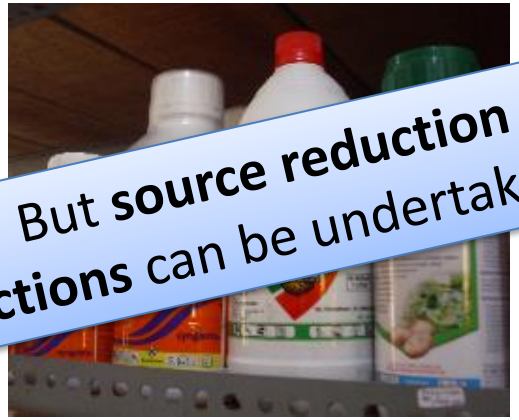
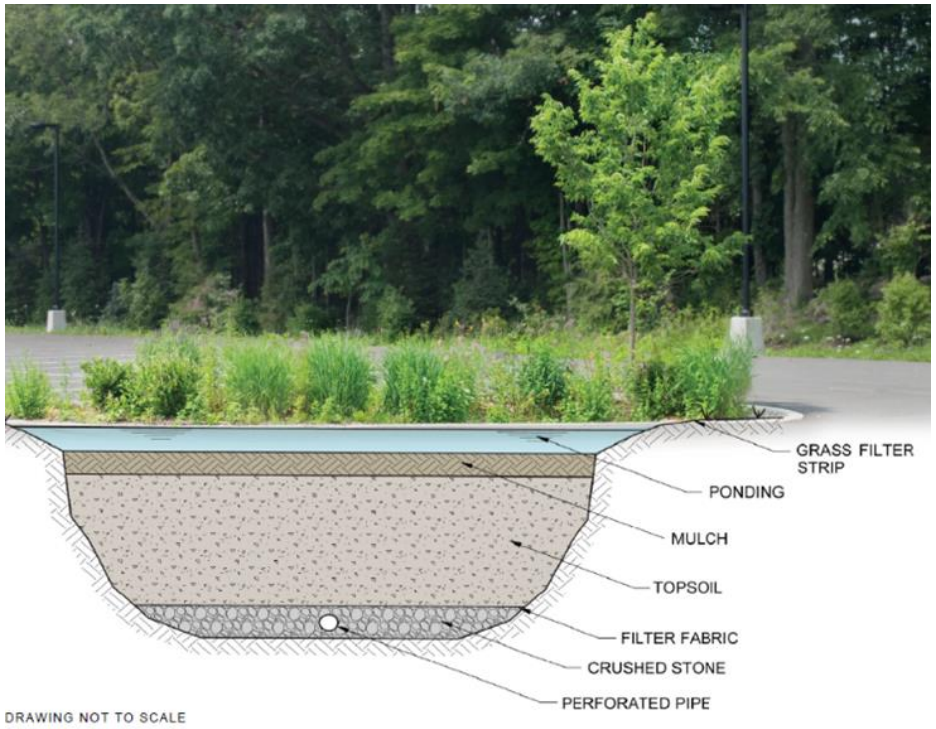


e.g. pesticides, biocides, BPA

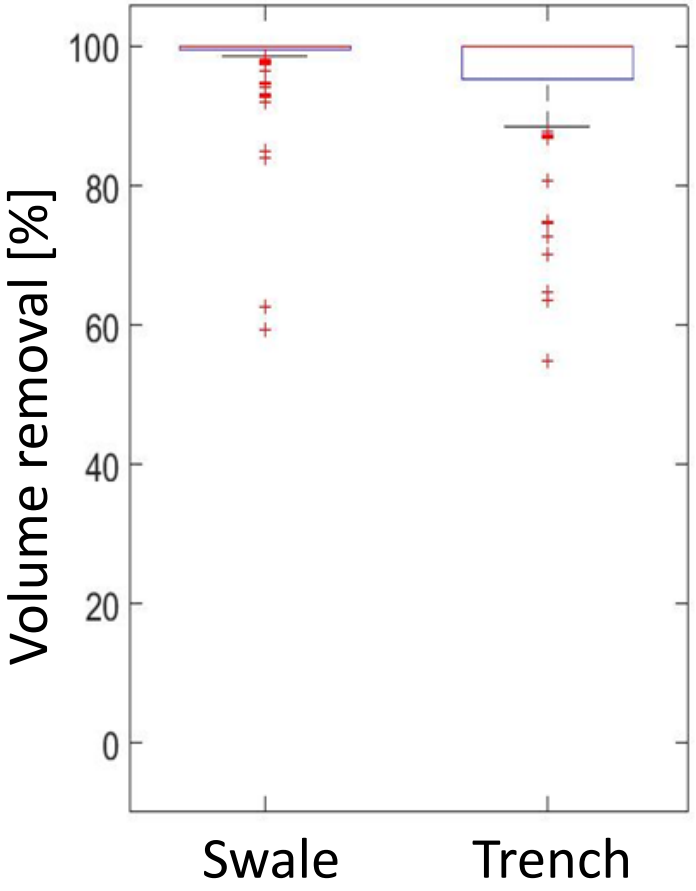
Is SuDS soil a good filter?

- **Water retention in soil plays a crucial role**

Case 1: Soil-based facility
with an underdrain



Picture: *State University of New York*

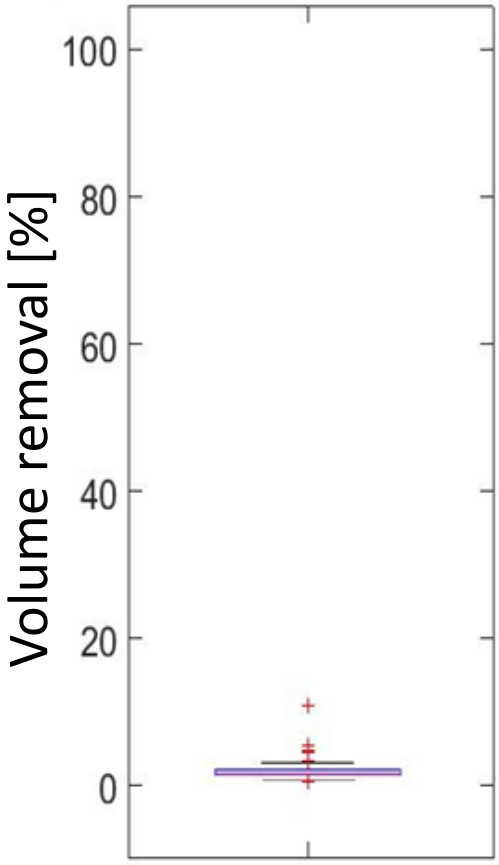


Is SuDS soil a good filter?

- **Water retention in soil plays a crucial role**

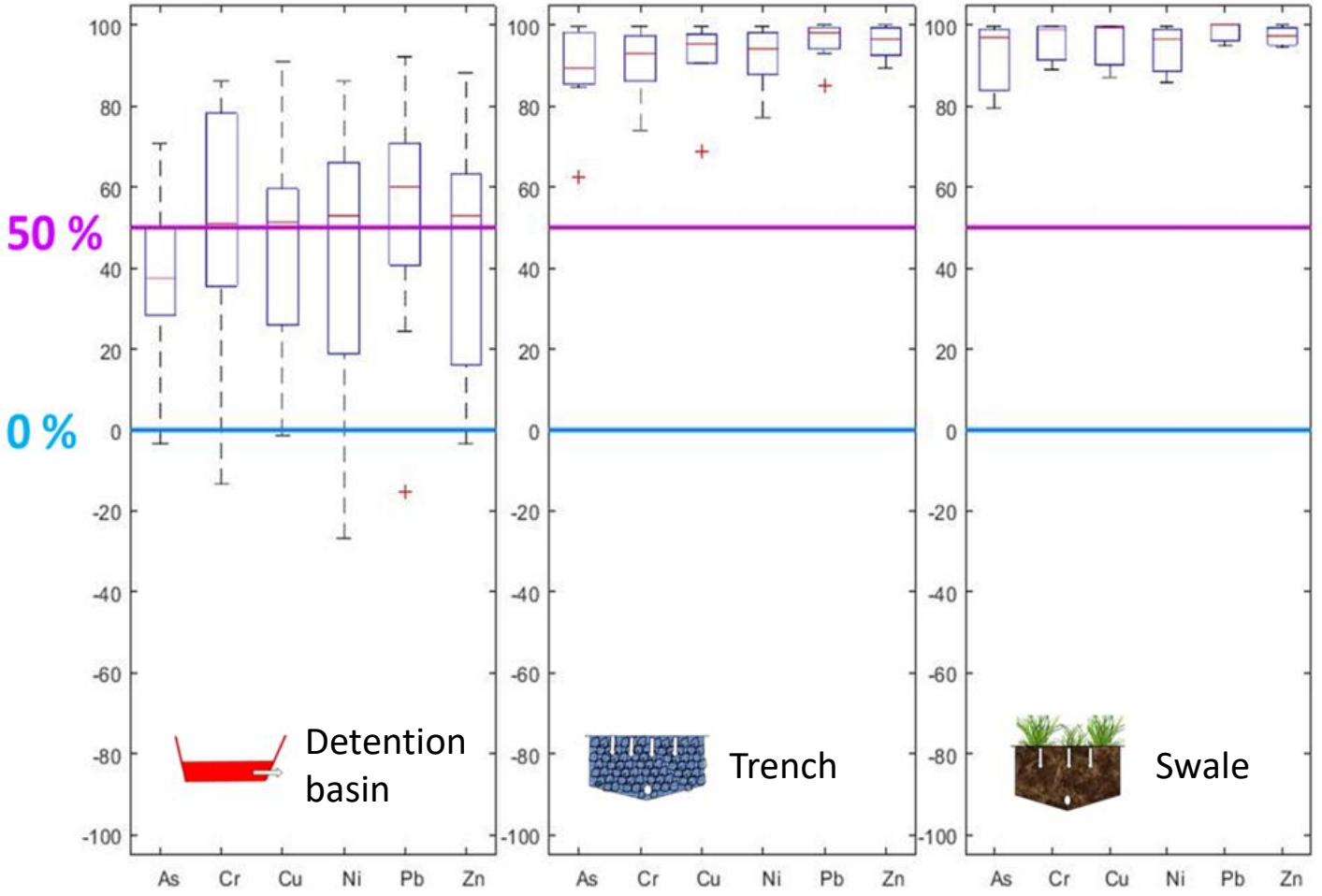
Case 2: Detention basin (with a concrete bottom, no infiltration)

Picture: OTHU, Lyon



Is SuDS soil a good filter?

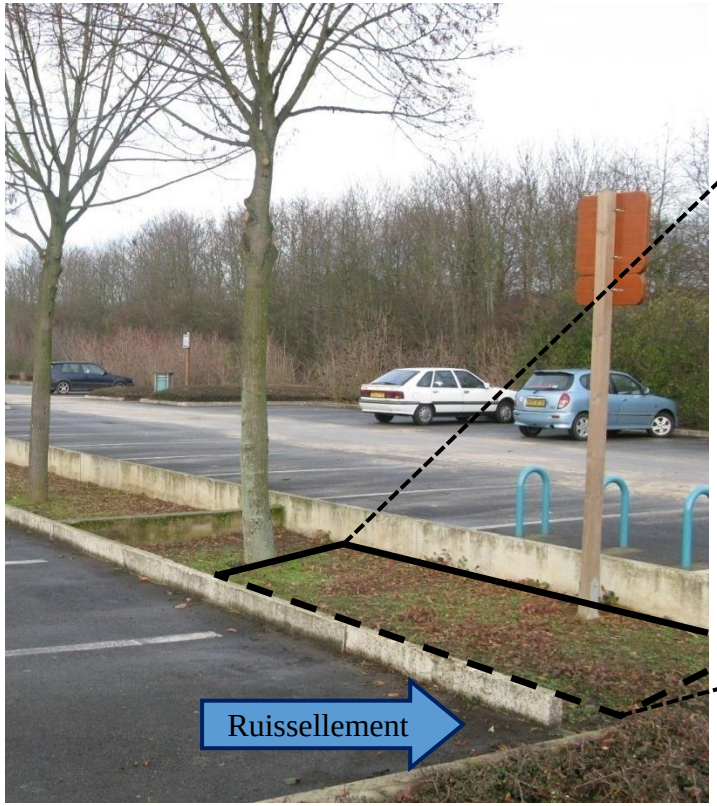
- **Water retention in soil plays a crucial role**
- **<u>Mass load removal</u> for metals in the 3 systems:**

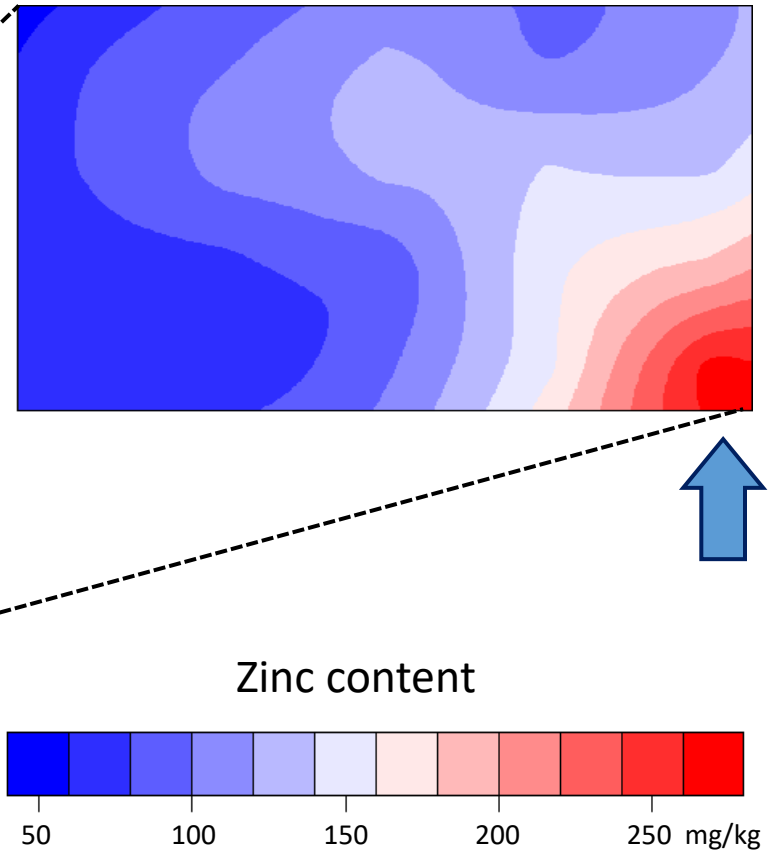


Garnier, 2020

Spatial distribution of contaminants in SuDS

- **In the surface soil**





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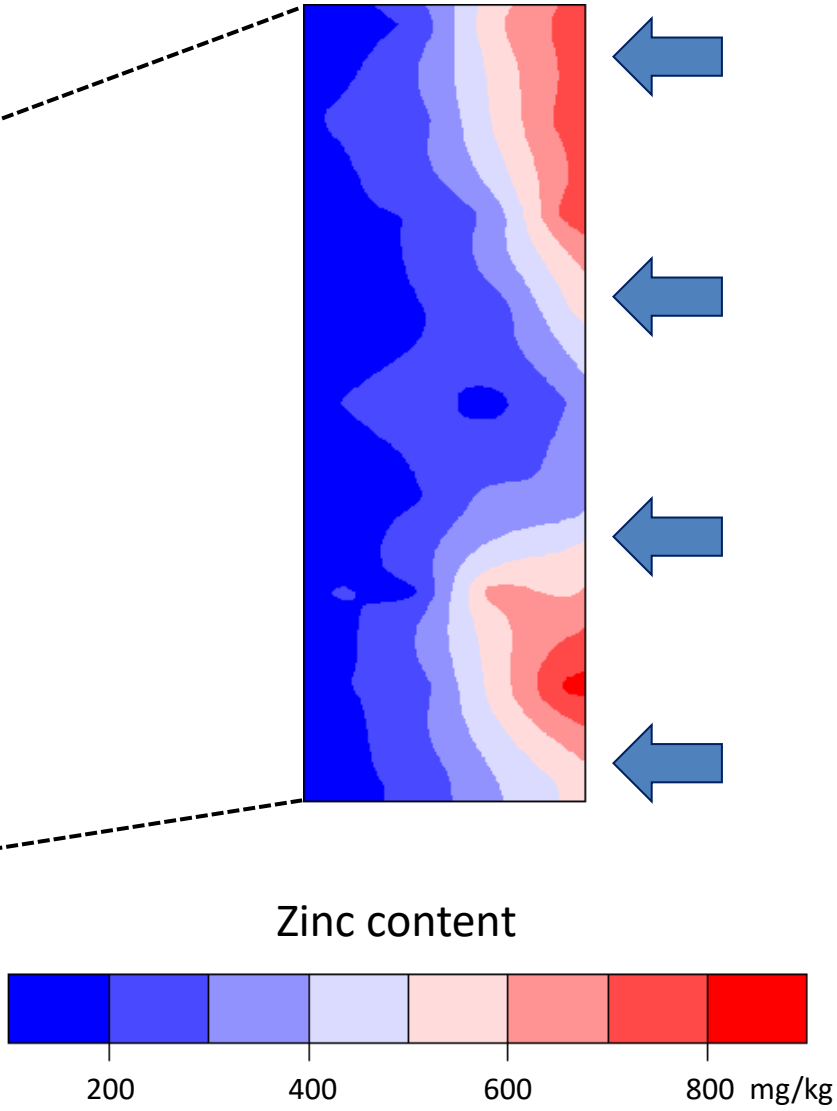

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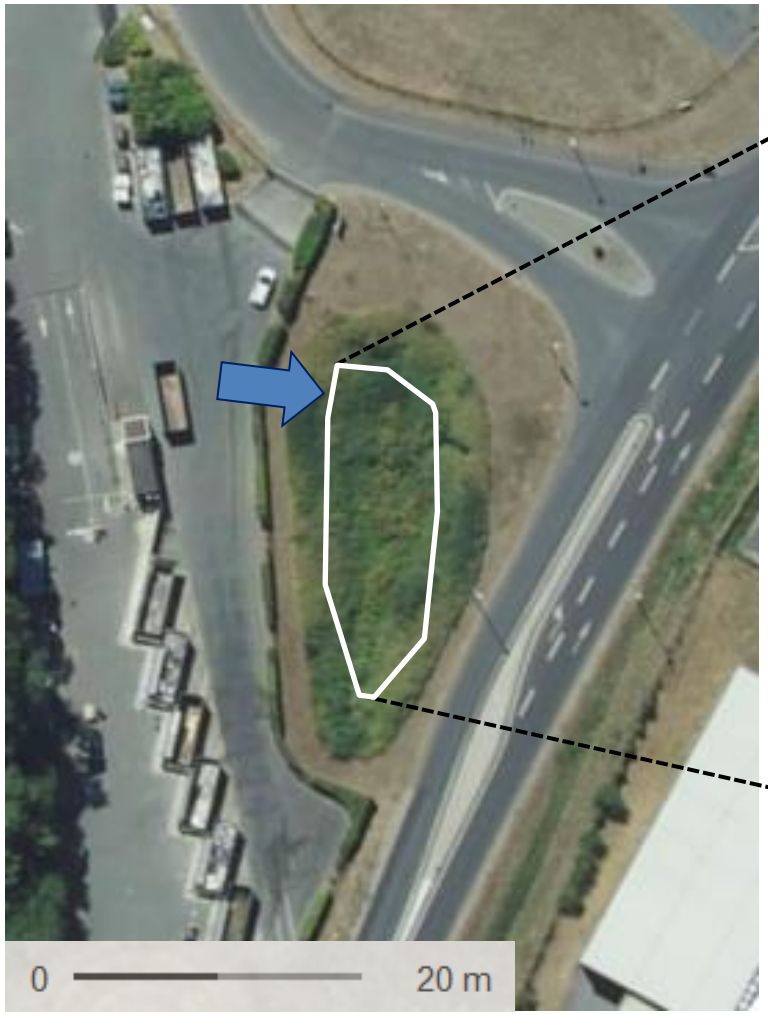

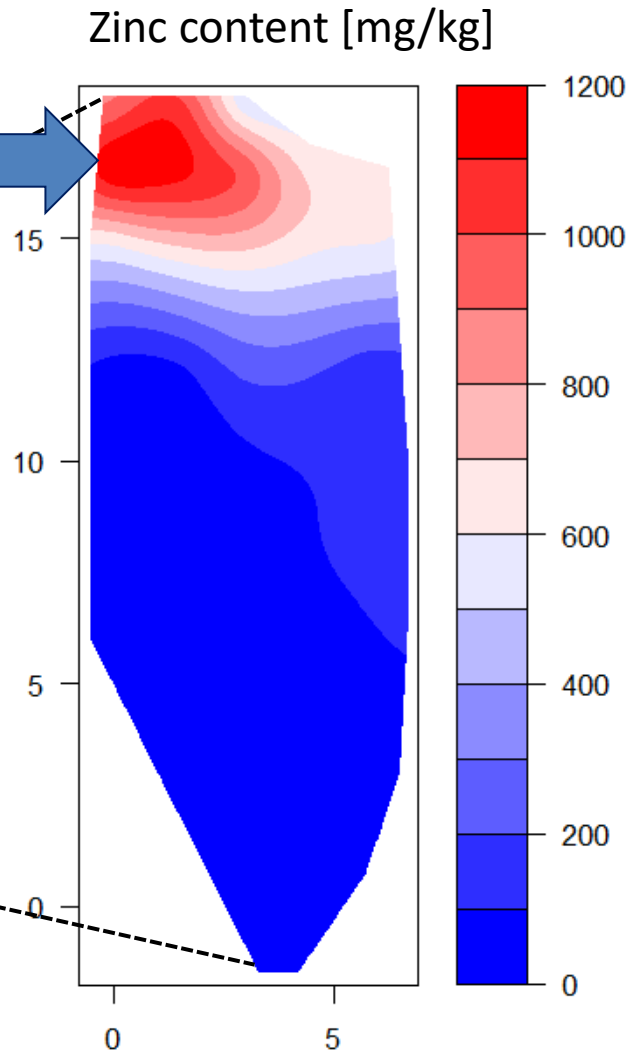

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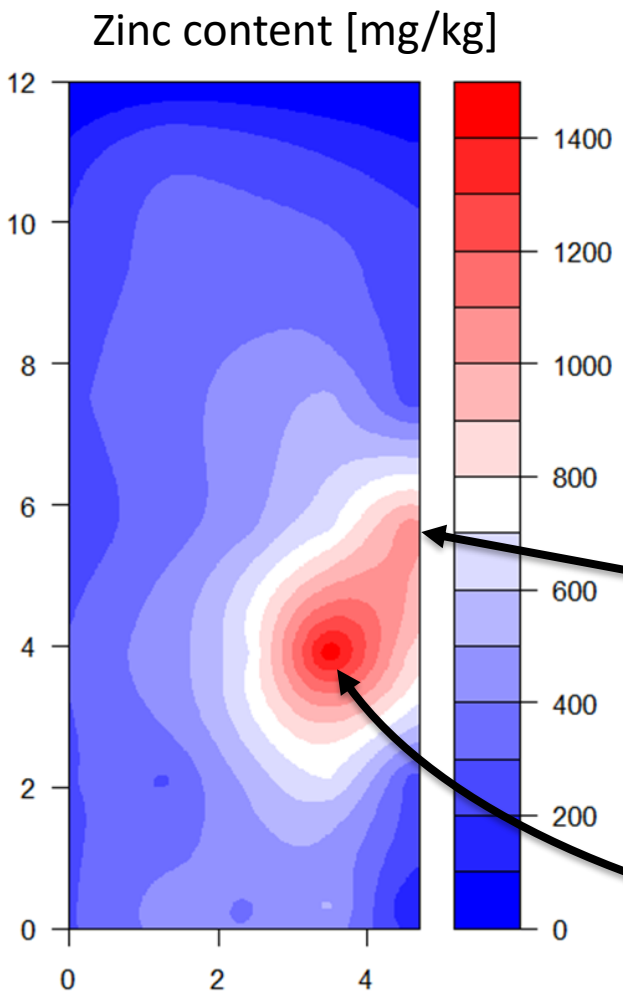
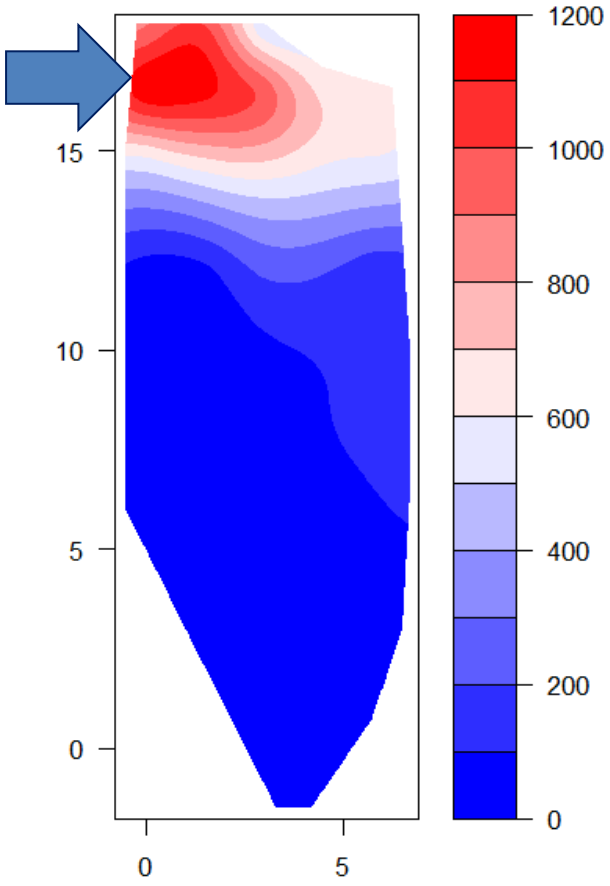


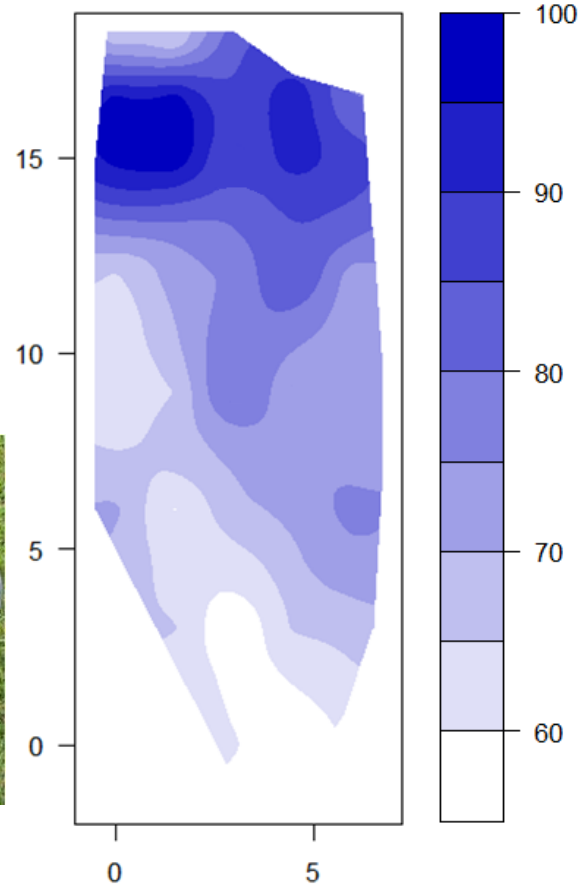
Spatial distribution of contaminants in SuDS

- **Signature of different hydraulic behaviors**
  - **Verification**: spatial measurements of the soil moisture

Zinc content [mg/kg]

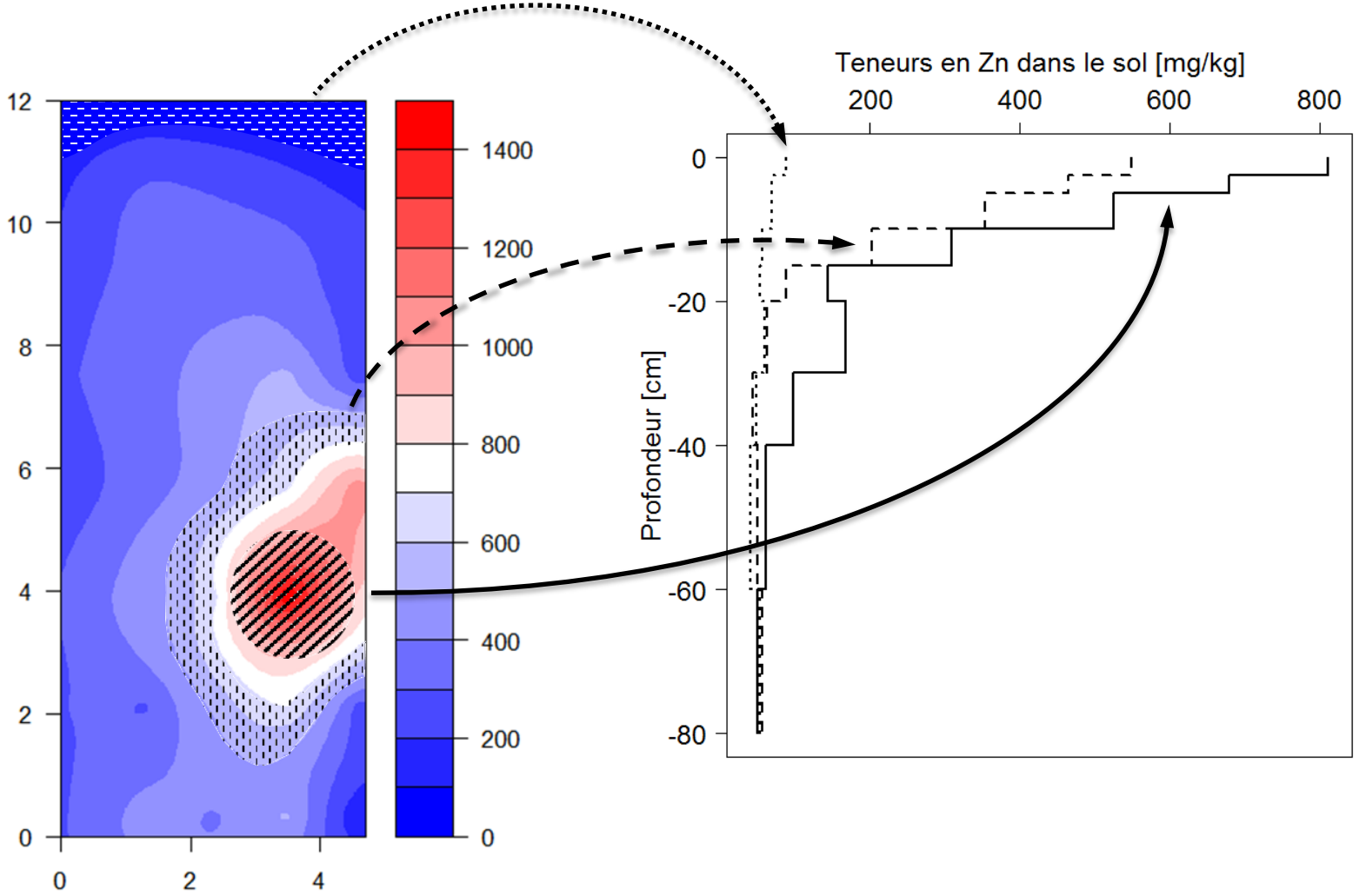


Soil moisture θ/θ_s [%]



Spatial distribution of contaminants in SuDS

- **Vertical profiles**



Spatial distribution of contaminants in SuDS

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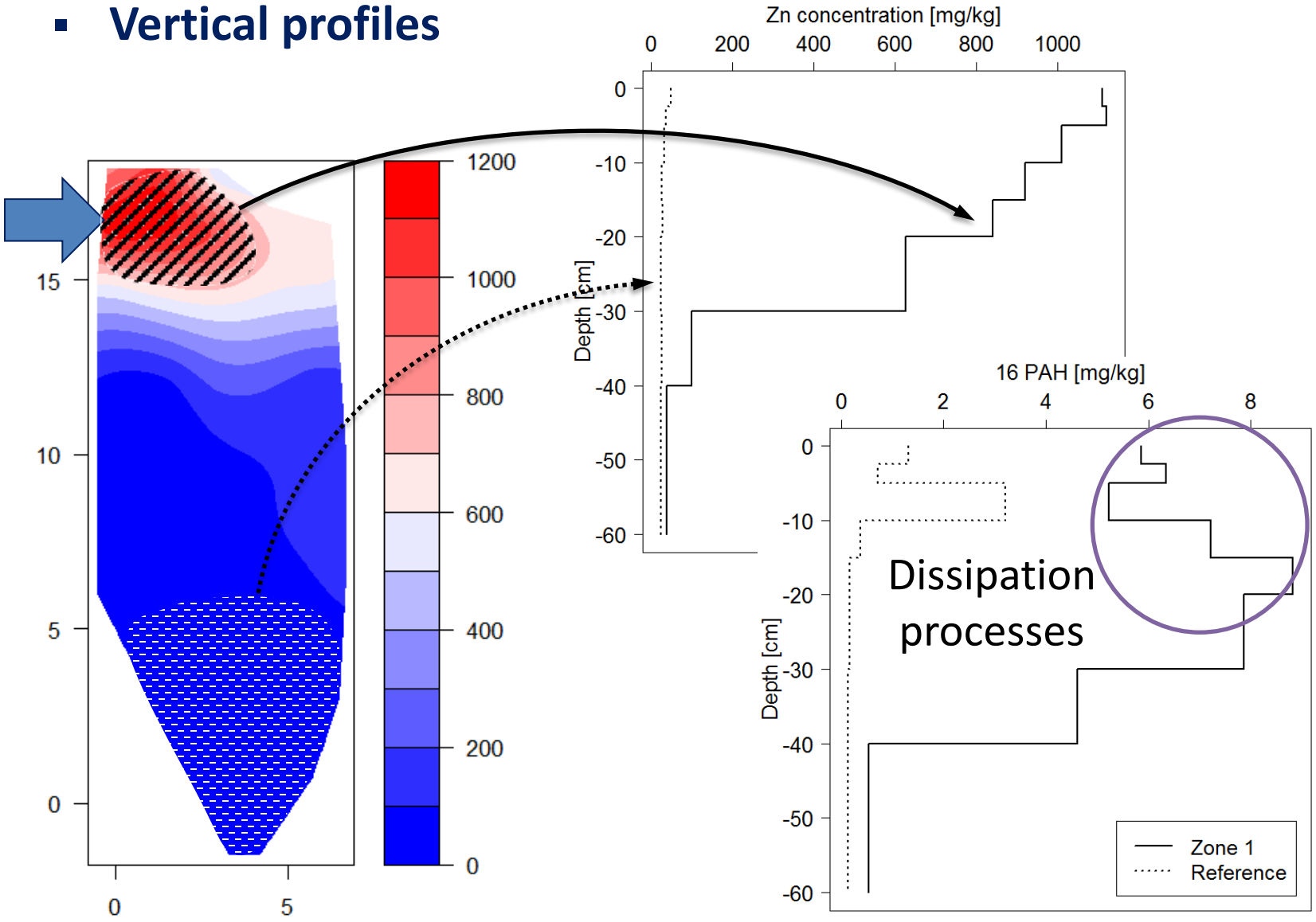
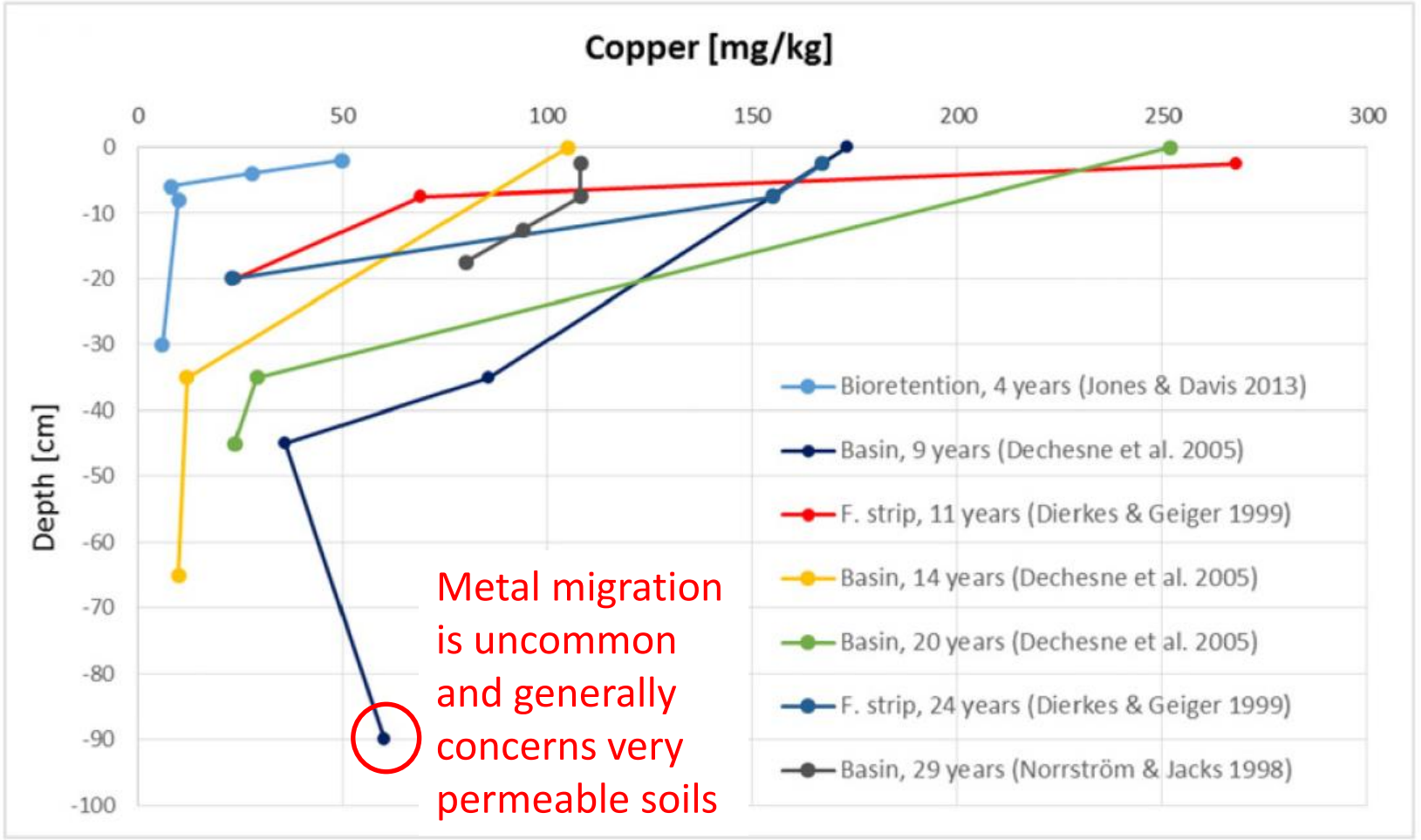


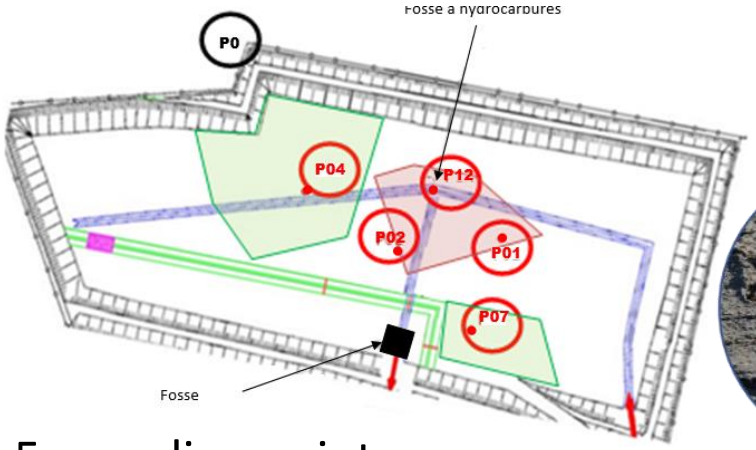
Spatial distribution of contaminants in SuDS

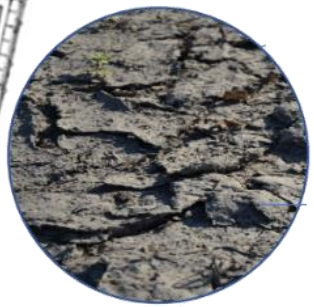
- **Vertical profiles – beyond the presented studies**

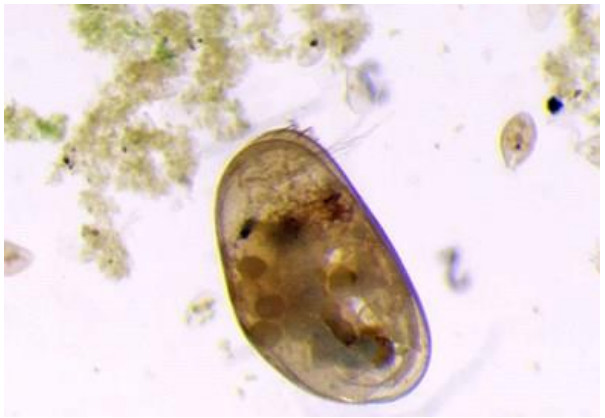


Tedoldi et al., 2016

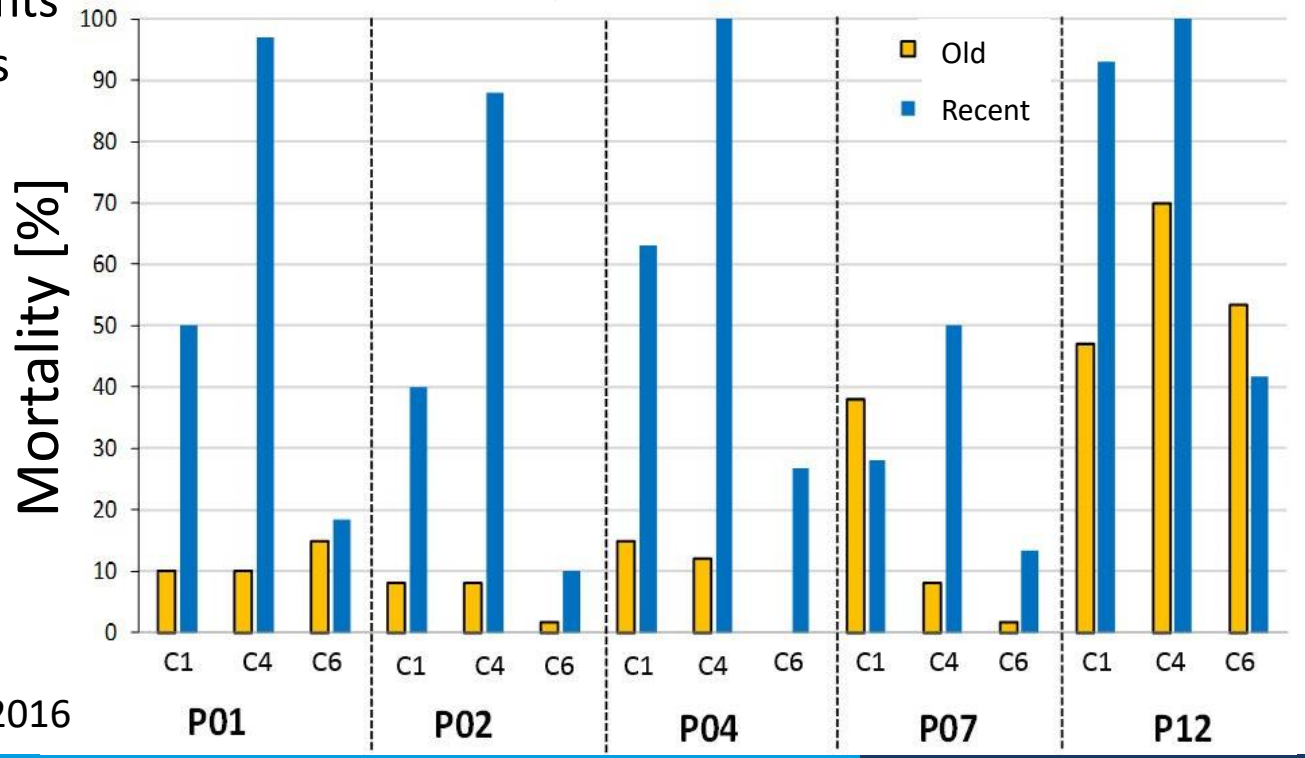
Environmental hazards?





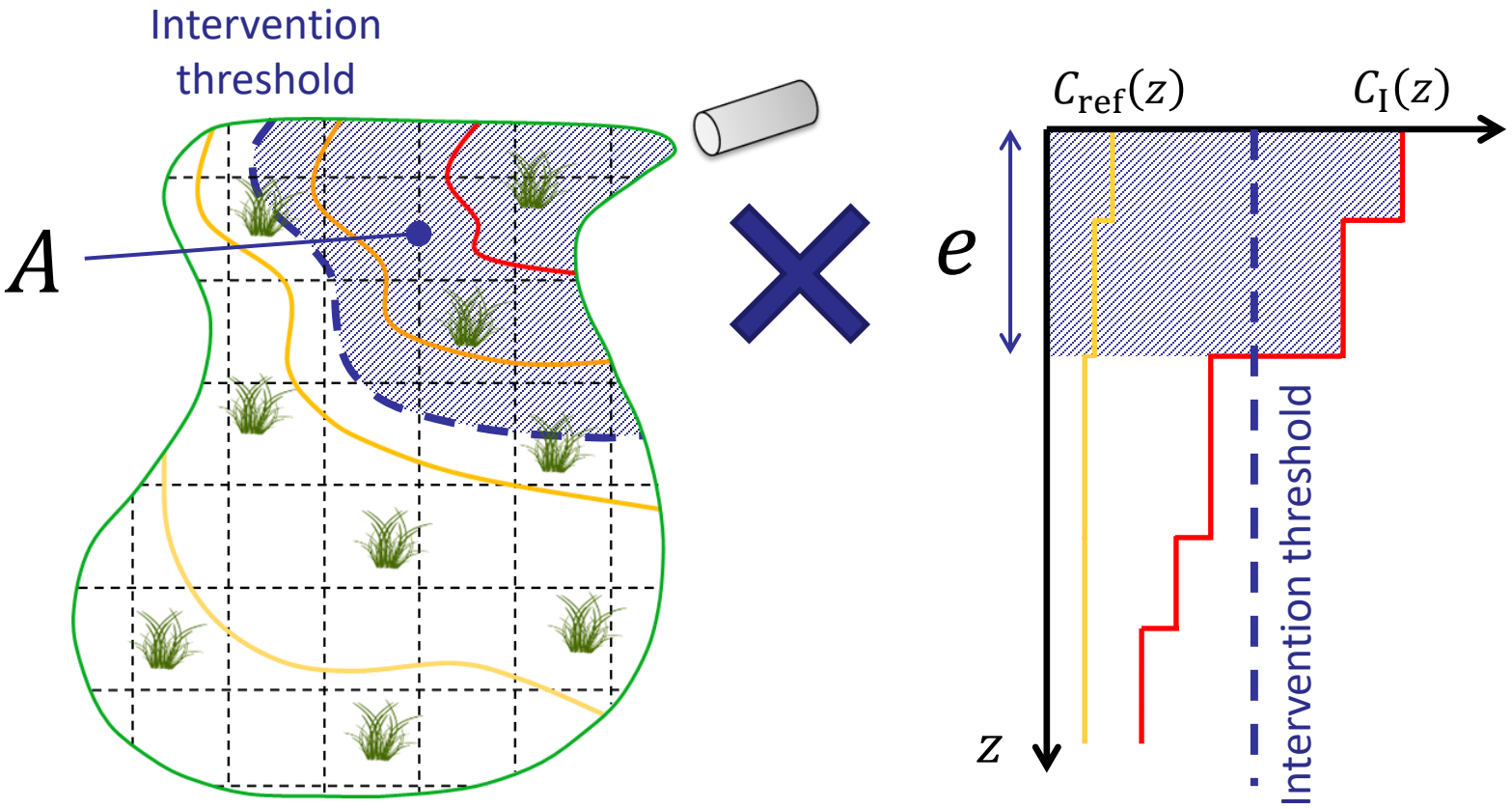


5 sampling points
× 3 campaigns



CABRRES project, 2016

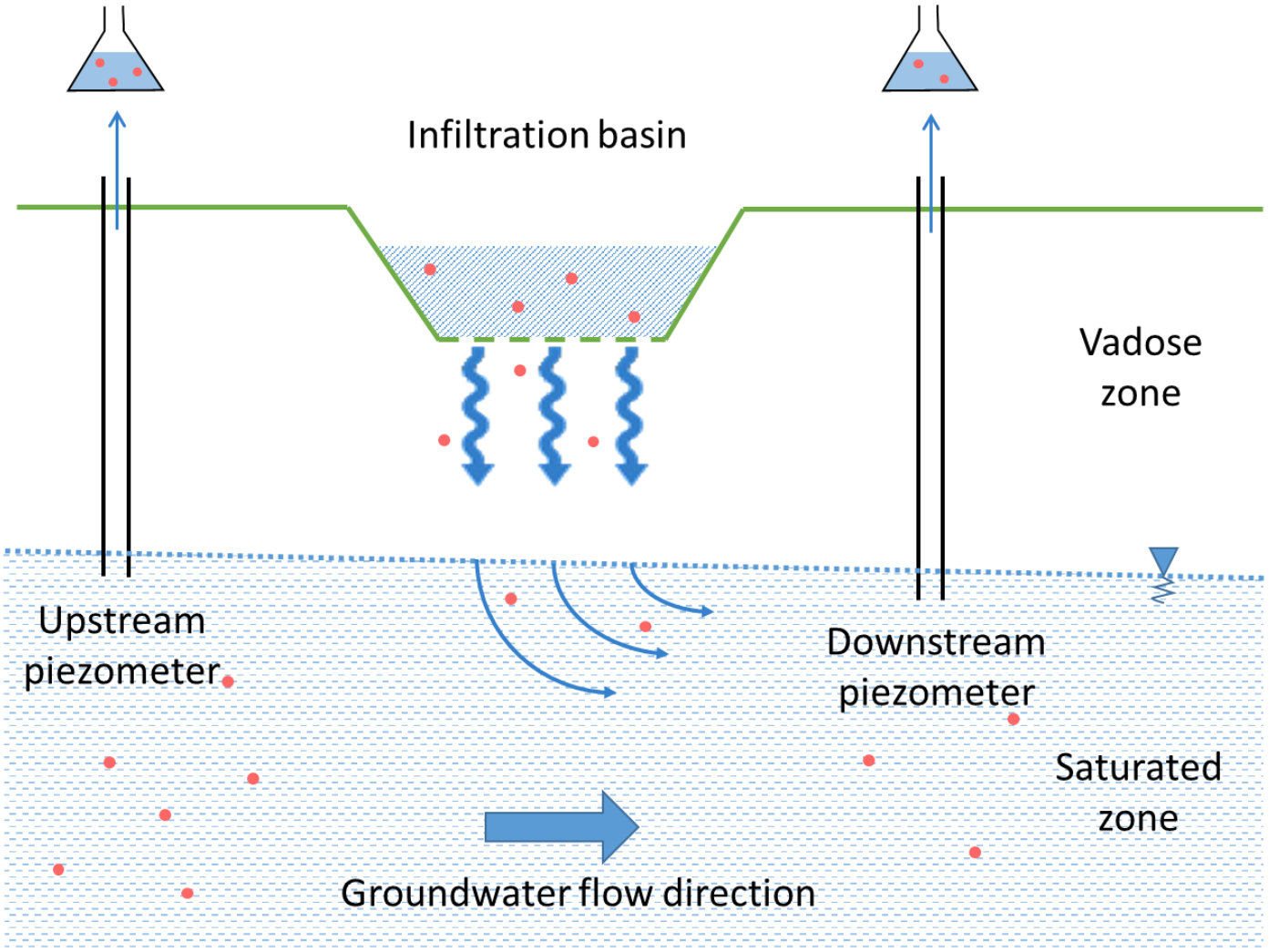
Needs for maintenance?



On average ~ 15 m³ of polluted soil per impervious hectare of catchment
after ~ 10 years of operation

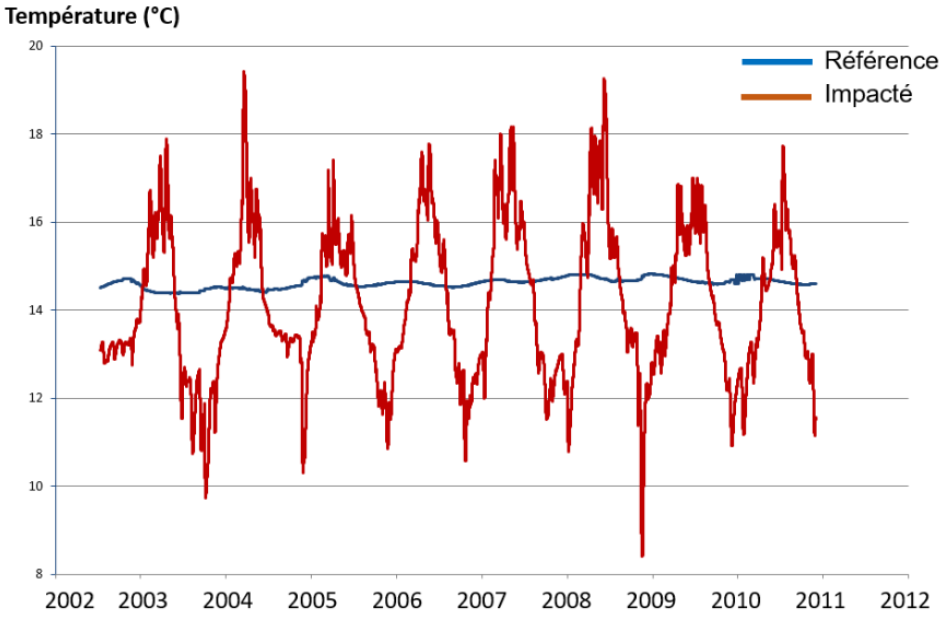
Possible impacts on groundwater?

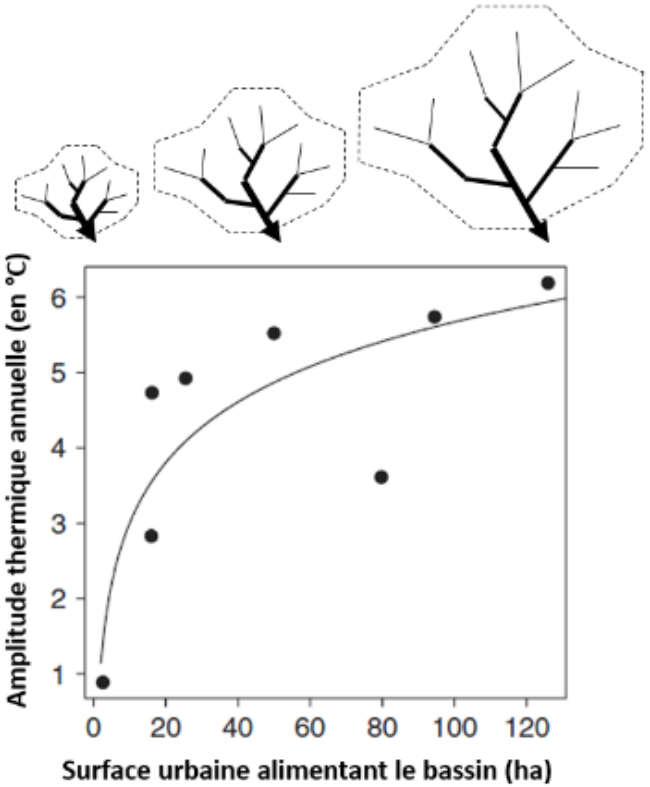
- **General principle:**



Possible impacts on groundwater?

- **Impact on groundwater temperature**
- Importance of the **catchment size**: large catchment lead to greater water and contaminant fluxes

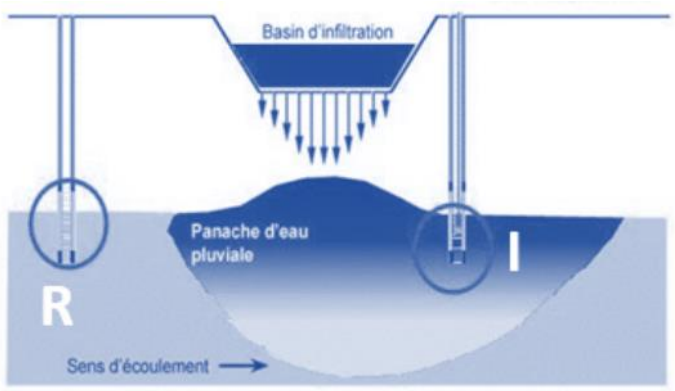




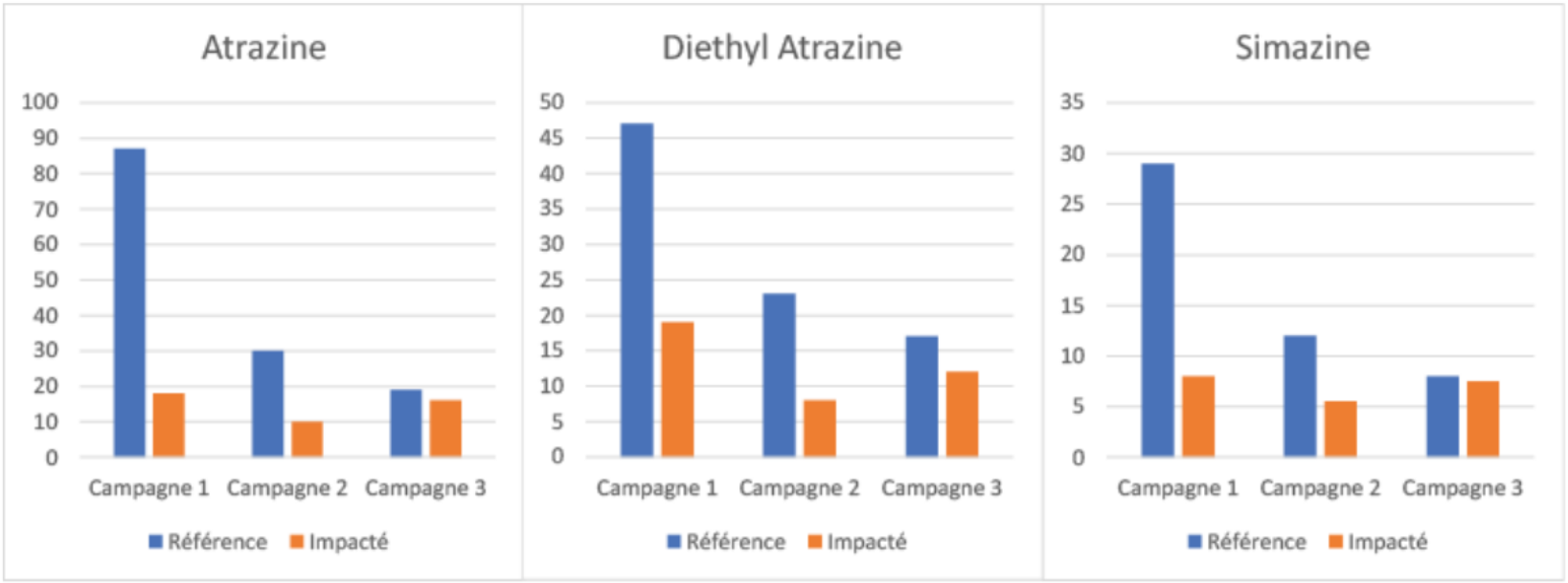
Data from OTHU, 2012;
Foulquier et al., 2009;
FROG final deliverable, 2022

Possible impacts on groundwater?

- **Impact on banned substances (e.g. some pesticides): groundwater dilution!**
- Accumulated amounts (ng) on a passive sampler placed in groundwater

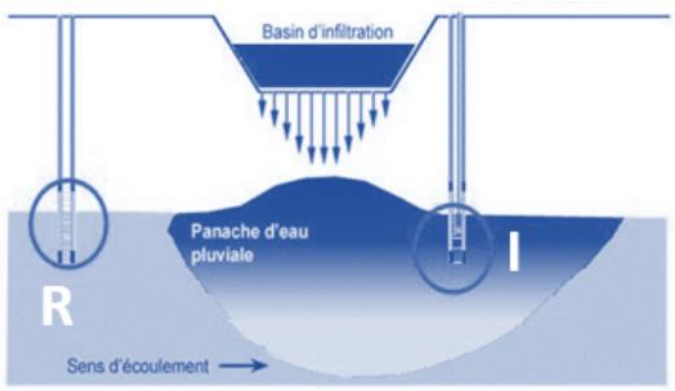


Pinasseau et al., 2020



Possible impacts on groundwater?

- **Impact on mobile pollutants: possible transfer towards groundwater…**
- Accumulated amounts (ng) on a passive sampler placed in groundwater



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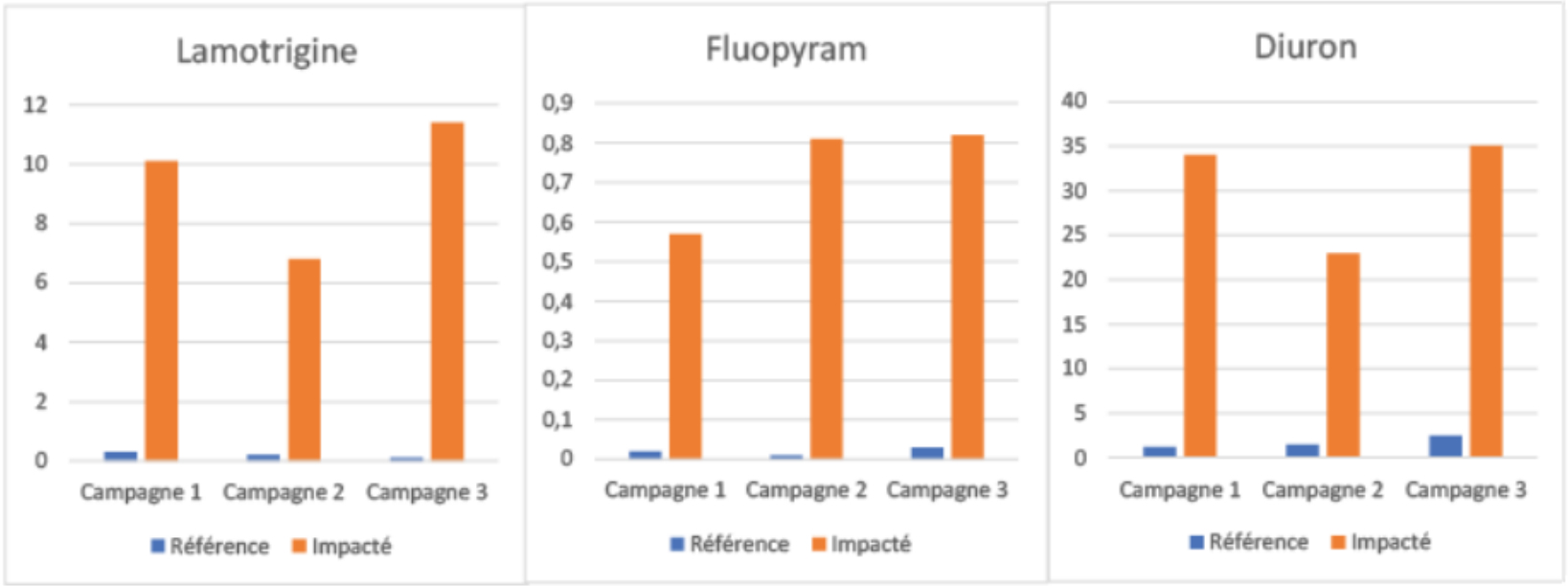

Conclusions

- **Stormwater infiltration preserves surface water quality**
- **SuDS soil acts as a filter towards most runoff contaminants, thus preventing impacts on groundwater**
- **Understanding the processes helps improve SuDS design and maintenance**
- **The typical distribution of contaminants reduces the cost and efforts of maintenance operations**
  - Horizontal extent governed by hydraulics
  - Vertical extent governed by retention processes
  - About 15 m^3 of polluted soil per hectare of catchment
- **The easiest contaminants to manage are the ones you don't emit! ⟶ Importance of regulations**

Tack så mycket!

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