

Nitrate dynamic and pathways in fractured limestone aquifers : From soil leaching to groundwater discharge in surface water

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Context of the study : Nitrate problematic

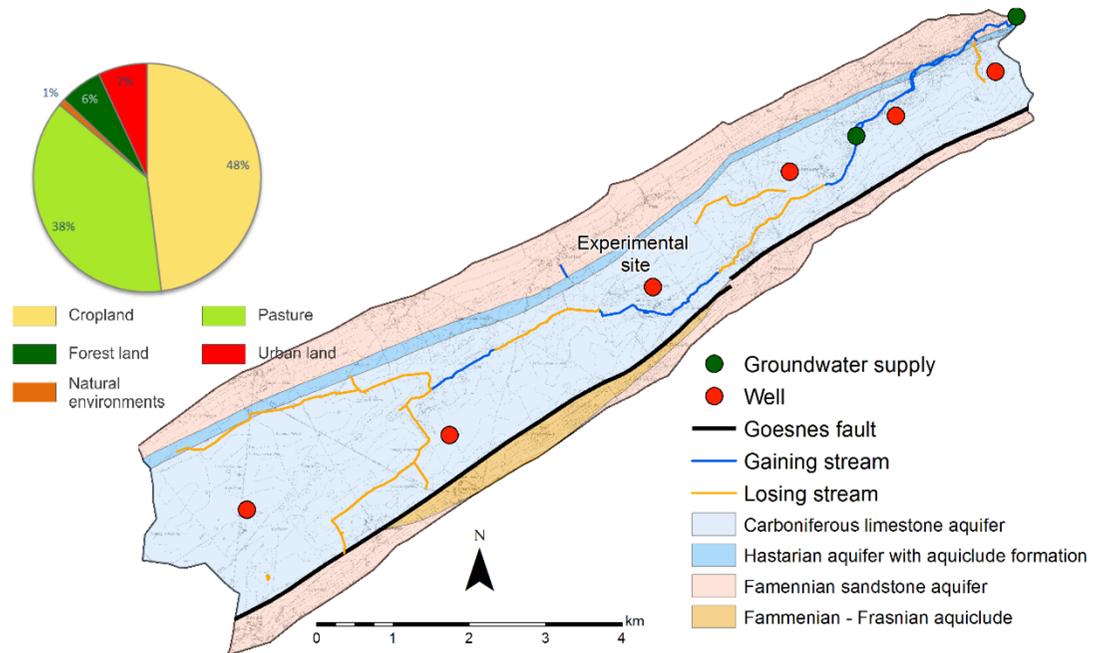
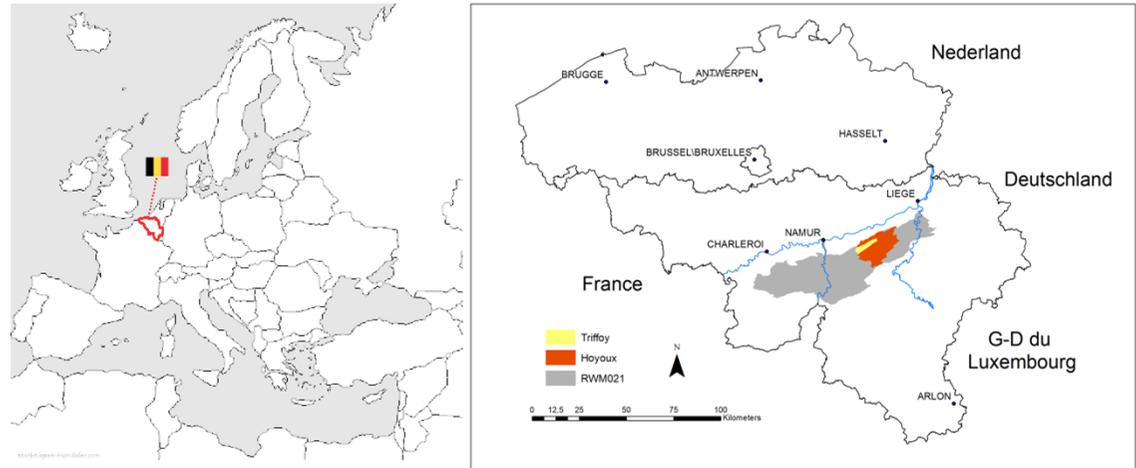
- One of the most widespread contaminant in the world
- High concentration and increasing trends in some aquifers (Drinking limit = 50 mg/l)
- Impact on stream quality (QS = 25 mg/l)

Nitrate dynamic and pathway already studied in various geological media but few studies focused on fractured limestones

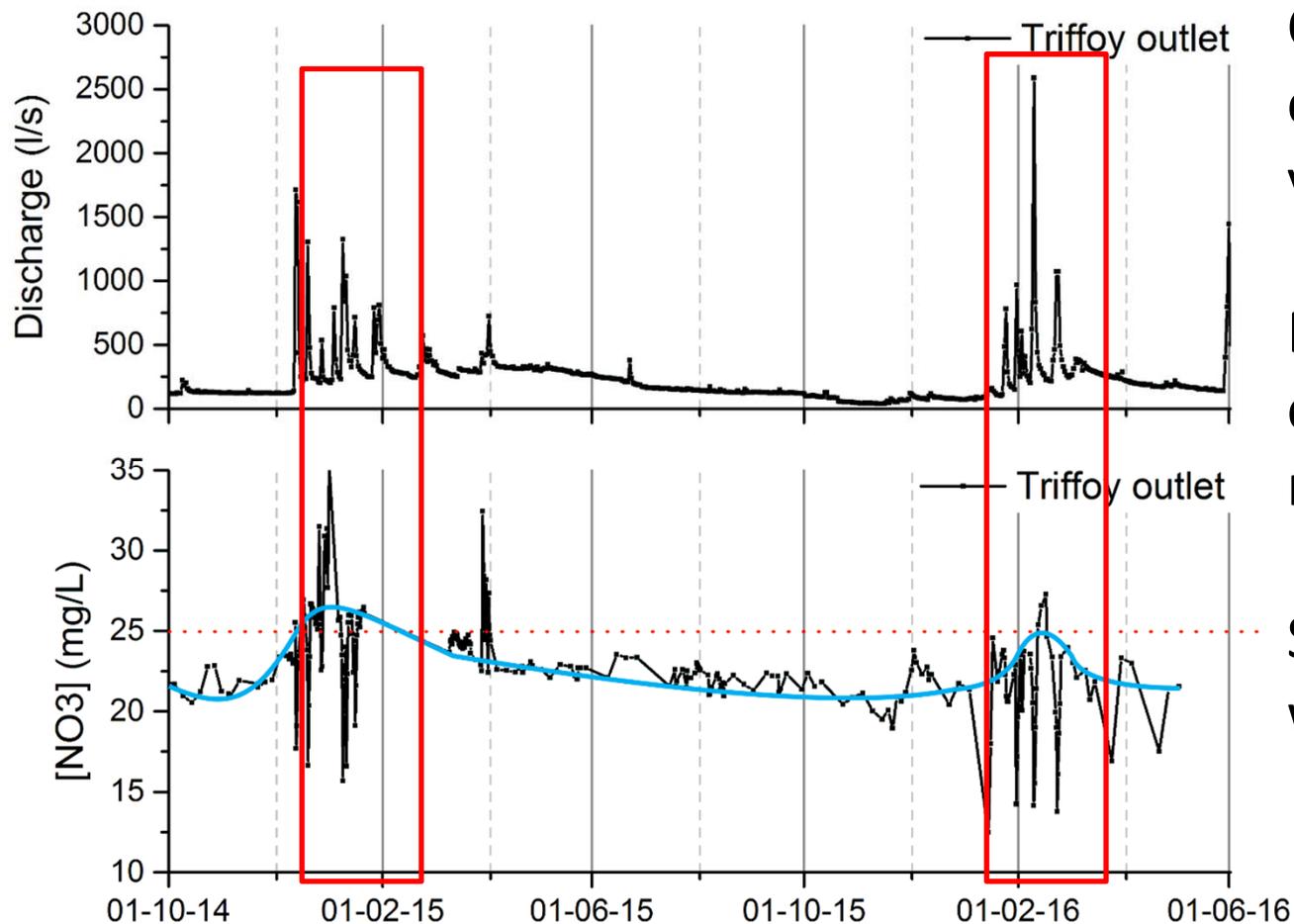
Case study : Triffoy watershed - Belgium

- Limestone synclines
- Sandstone anticlines
- Agricultural catchments

- Multiple private wells
- 2 galleries for drinking water supply



Triffoiy watershed : Nitrate concentrations in the river

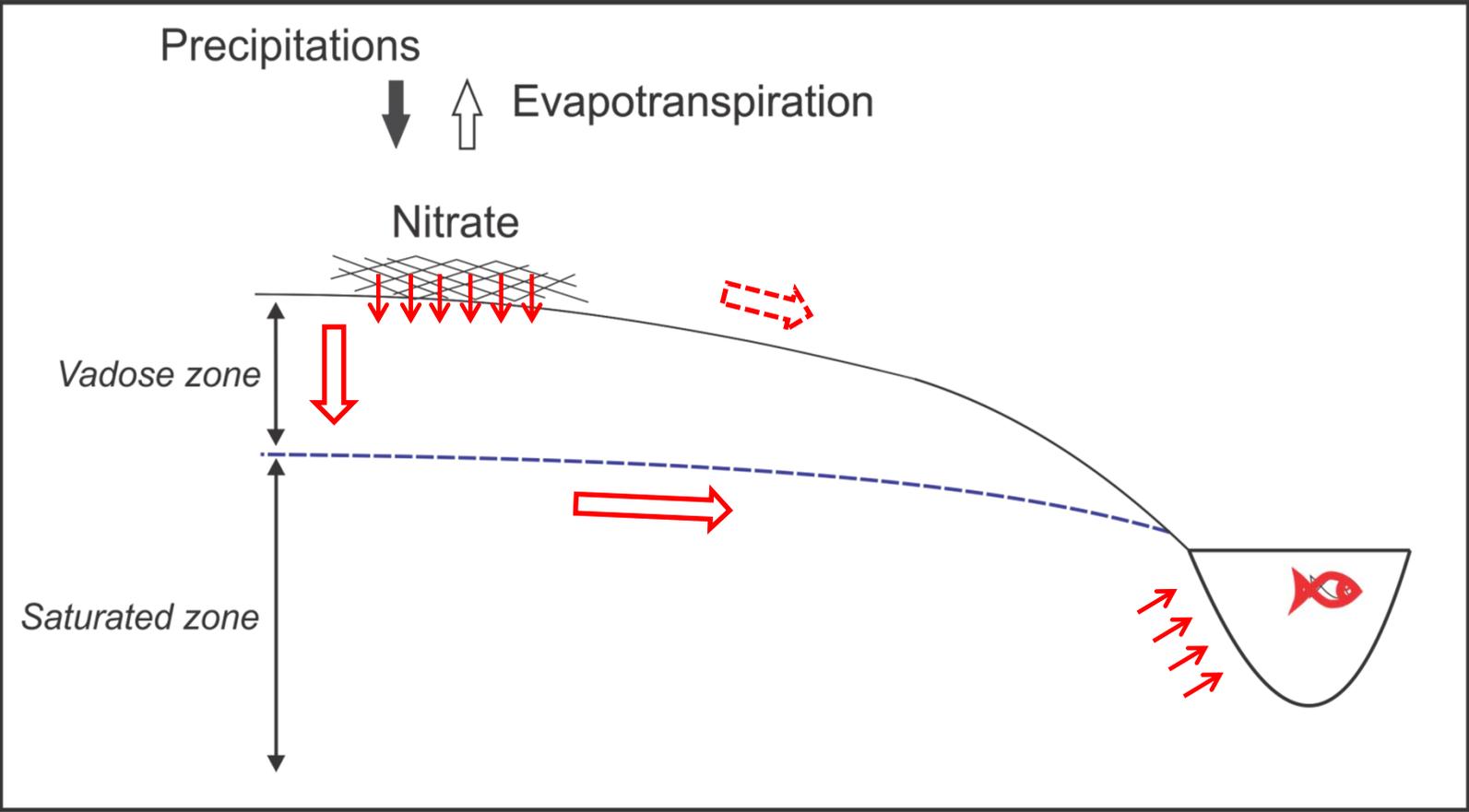


Concentration constant all over the year (~22mg/L)

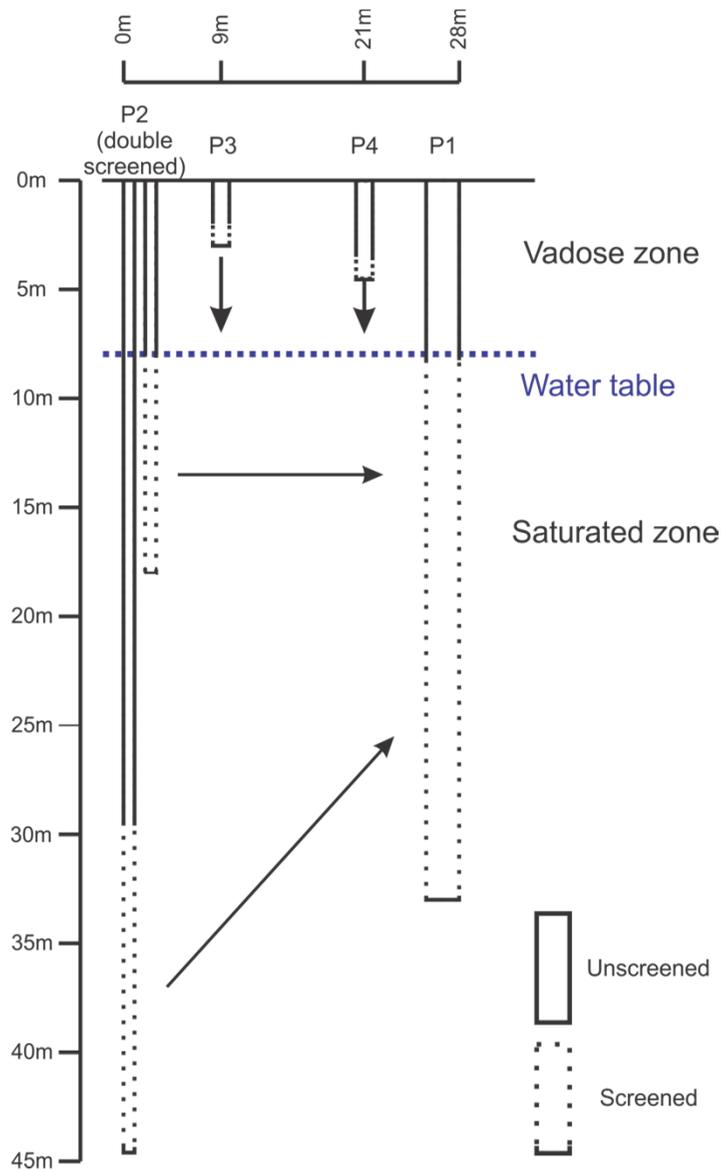
Decrease of concentration due to runoff and dilution

Systematic increase in winter (up to 35mg/L)

How can we explain these observations?



Experimental site



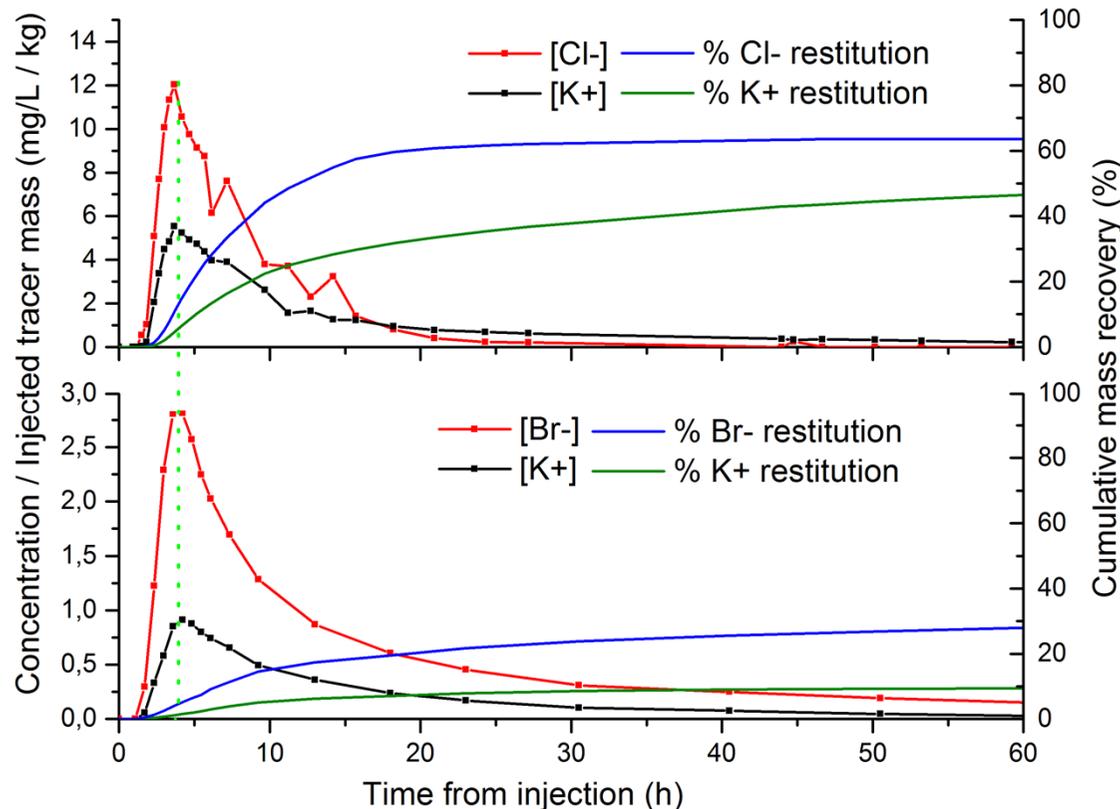
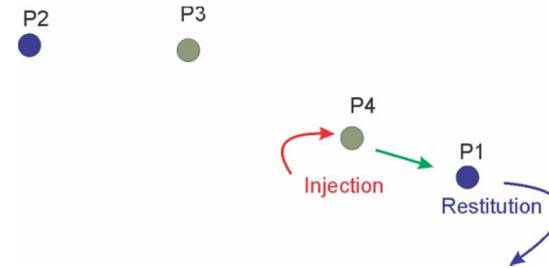
Assess mechanism and travel time in vadose zone and groundwater with applied tracer experiments



Mechanism and travel time : vadose zone

Two types of tracer injection in P4 :

- (1) KCl with water pounding in the piezometer
- (2) KBr with no recharge



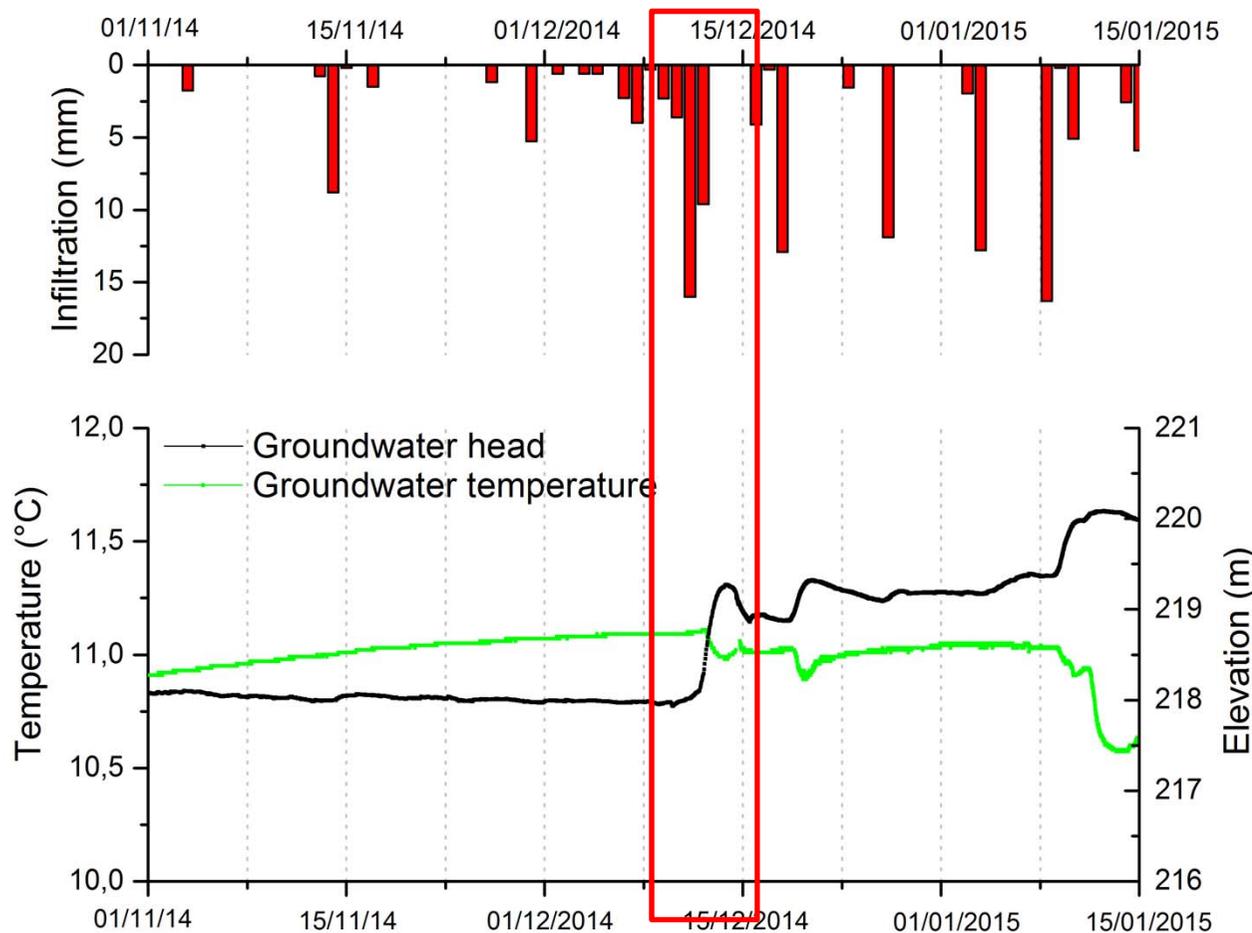
In both case :

- 1st arrival : 1h30 / Modal time : 4h
- Short travel time in vadose zone ($v_{max} = 1.33$ m/h, $v_{mod} = 2$ m/h)
- No impact of water pounding on travel time

→ Fast preferential flows

Impact of rainfall event on groundwater

Same observation using groundwater head and temperature monitoring



Fast response of groundwater levels and temperatures

Nitrate monitoring & sampling

Monitoring of nitrate concentration in both groundwater and surface water

Groundwater

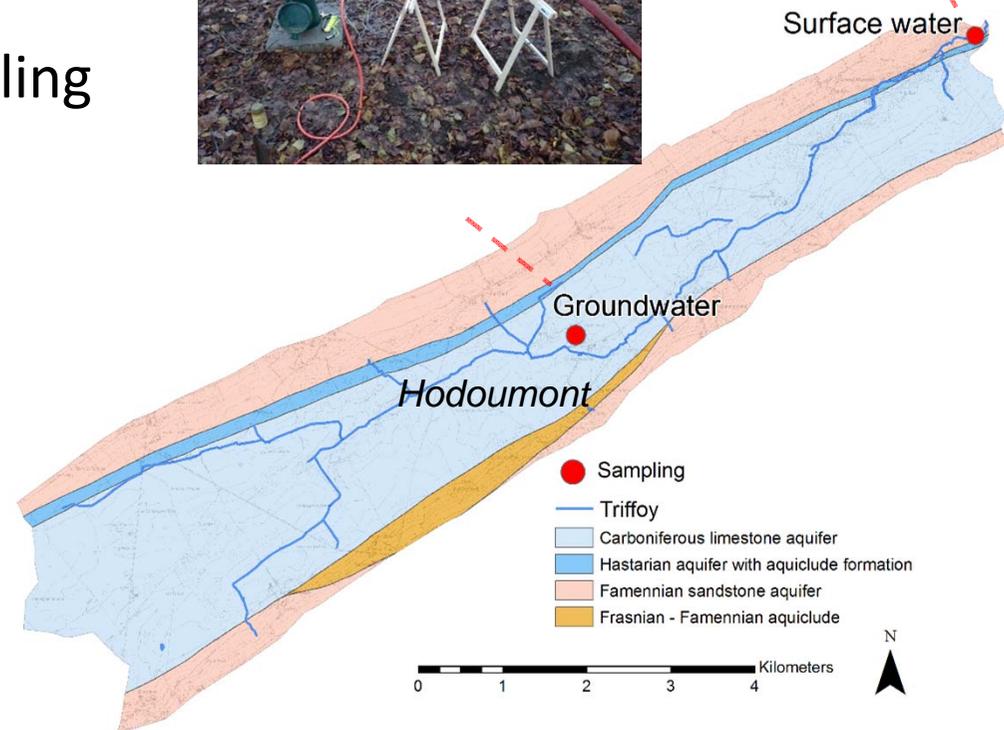
- Experimental site wells
- Monthly to weekly sampling
- Manual sampling

Surface water

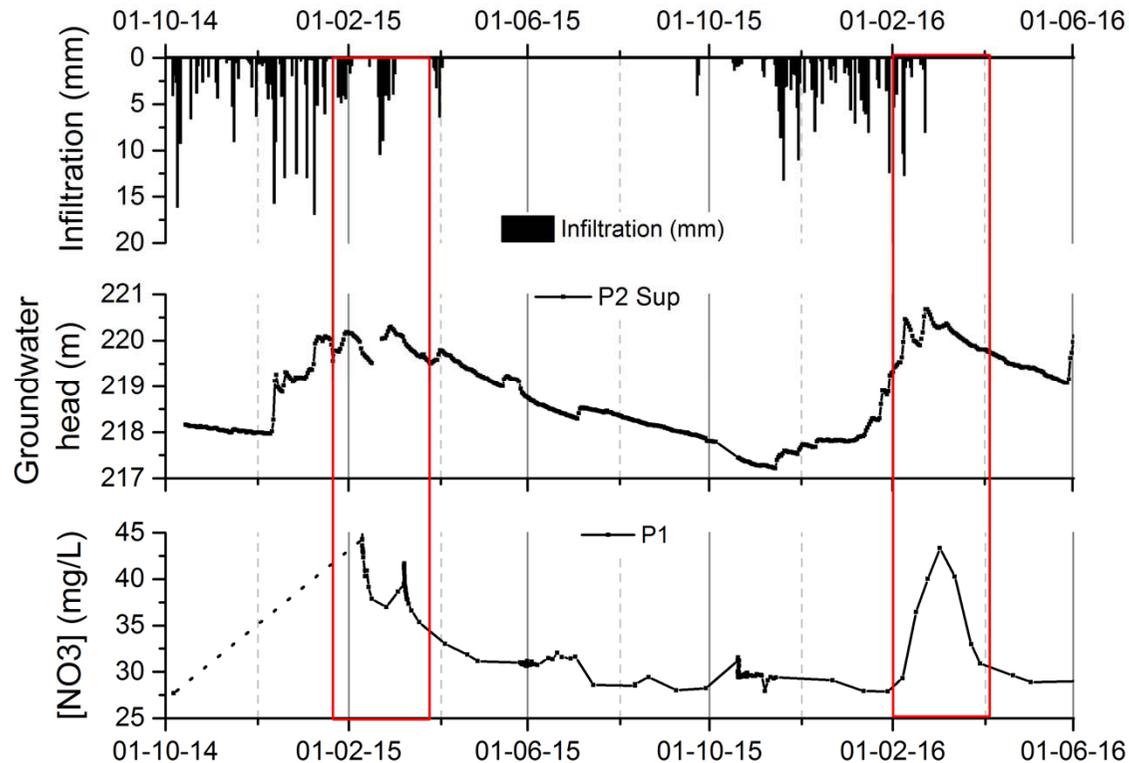
- Outlet of the basin
- Daily sampling using automatic samplers
- High frequency monitoring using a nitrate probe



Triffoy



Nitrate monitoring : Groundwater

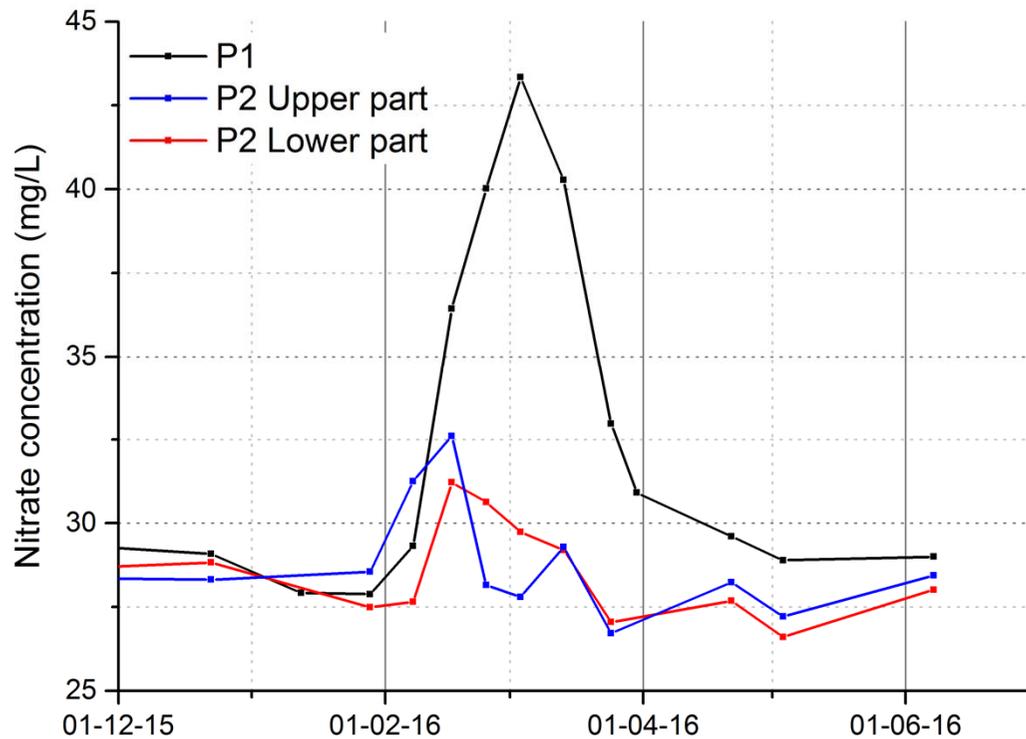


Concentration constant all over the year (~30mg/L)

Increase in winter (up to 45mg/L) after important rainfall event

=> Synchronous increase of nitrate in groundwater and surface water

Nitrate monitoring : Groundwater



Increase of nitrate observed faster and with higher concentrations in the superficial wells

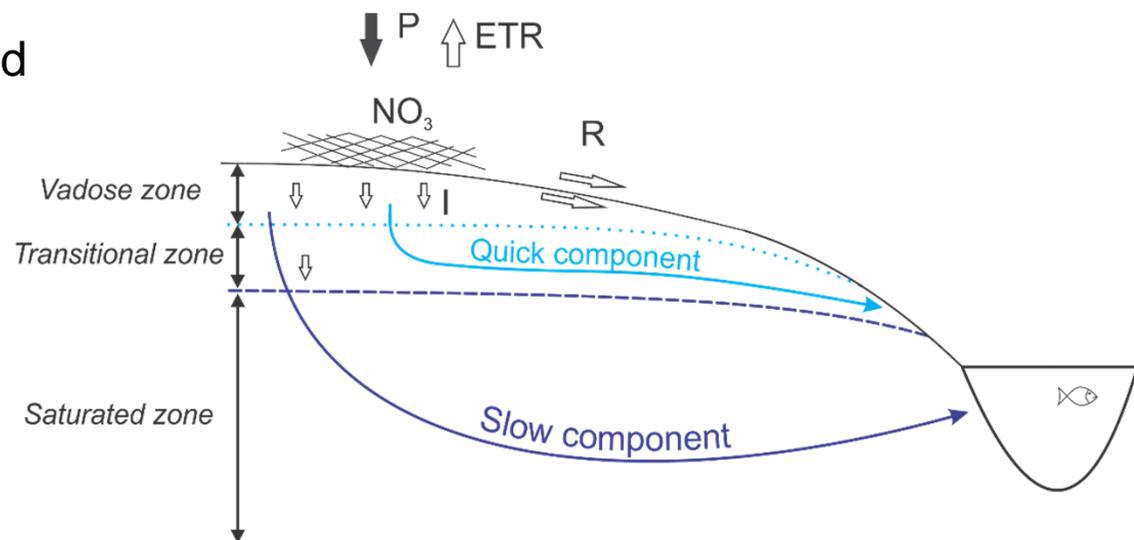
Conclusions (1)

Fast nitrate transfer between soil – vadose zone – groundwater – stream :

- Leakage of residual nitrate from soil during infiltration in winter
- Fast preferential flows in the vadose zone
- Two components in the saturated zone:

(1) Fast component of flow and nitrate transfer in the altered upper part when groundwater level increase

(2) Slow component with baseflow and mean nitrate concentrations



Conclusions (2)

For water managers :

- Sampling frequency to be adapted to the dynamic of the pollution
- No storage of nitrate in the vadose zone => fast decrease of concentration in groundwater if changes in agricultural practices
- Surface water quality directly dependent of groundwater quality
- Increase of nitrate concentrations in surface water in winter could be mitigated using catch crops

Selected case study by EU Groundwater Working group :

Technical Report on Groundwater Associated Aquatic Ecosystems, 2015,
Technical Report n°9 - Unit C1 Water, European Commission

Acknowledgements

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