Three years monitoring of pesticides mitigation with an artificial wetland receiving agricultural drained flow at catchment scale

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Champigny Recharge Specificity

60% of the recharge is due to direct infiltration from surface water to groundwater (sinkholes).

One of the 42 sinkholes

→ Vulnerability from agricultural pollution
Propose and test a methodology on an example to be reproduced for the whole Champigny Hydrosystem

Selected Objective: PESTICIDES MITIGATIONS from Agricultural Land by
1) Reduction of 50% of total pesticide applied amount and secondly reduction Nitrate pollution
2) Support for Implementation of Artificial WETLANDS

Involvement of all the stakeholders:
• Water Agency: Water Framework Directive
• Local authority: Drinkable water to citizens at a lowest treatment as possible
• Farmers: Food production
• And Scientists: Improve knowledge and provide solutions, tools …
Objectives of the RAMPILLON project

PROTECT GROUNDWATER FROM PESTICIDE CONTAMINATION IN A TOTALLY DRAINED WATERSHED OF 400HA

After land reclamation, all buffering systems disappeared
Co-construction: a step by step process

When involving a group of farmers, the process takes a long time!!

Tournebize et al., 2012
Tested water flow interception strategies

**2014-2015**

**In Stream**
- Drained plots

**Artificial wetland**
- Shallow
- Limited max inlet \( Q \)
- Vegetated
- Remediation purpose

**2012-2013**

**2013-2014**

**Off Stream**

**Drained plots**

**Buffer zone**
- Shallow
- Vegetated
- Remediation use only

**Drainage pipe or ditch**

**Hydraulic management**
Main Artificial WETLAND
6300M² AND 2400M³ FOR 400HA (0.15% OF UPSTREAM WATERSHED, 6M³ PER DRAINED HA)

Outlet
With controlled leakage

Inlet Gate (opening / closing management)

Water depth: 1.3m

Water depth: max 0.5m

Water depth: 0.8m
Ecological trajectory: Vegetation (macrophytes)

Sedge (Carex) - Reed (Phragmites australis) – Cattail (Typha latifolia) – Bulrush (Juncus) – Algae

80% vegetation cover in 2012 – 20% vegetation cover in 2013 – 50% vegetation cover in 2015
Monitoring Strategy

**Catchment OUTLET**
- Continuous discharge monitoring (30min)
- Weekly Grab Sampling for pesticides and nitrate

**AW OUTLET**
- Outlet Flow Control
- Continuous discharge and nitrate concentration monitoring (30min)
- Weekly Grab Sampling for pesticides and nitrate

**Ditch from 400ha catchment**

**Artificial WETLAND:**
- Surface = 1ha (Ratio: 0.15%)
- Volume = 2400 m$^3$
- Eddy tower

**AW INLET**
- Input Flow Control (OPEN /CLOSE Strategy)
- Raingauge
- Continuous discharge and nitrate concentration monitoring (30min)
- Weekly Grab Sampling for pesticides and nitrate

**Coupling high frequency monitoring (Q, R, ET, SM, NO$_3$)**
Weekly flow weighted sampling
# Hydrological Results

## Yearly Rainfall and Subsurface Drained Flow in mm (from October to September)

<table>
<thead>
<tr>
<th></th>
<th>2012/13 &amp; 2013/14</th>
<th>2014/2015</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proportion Winter / Other seasons</strong></td>
<td>85/15%</td>
<td>80/20%</td>
</tr>
<tr>
<td><strong>Opening days of inlet gate</strong></td>
<td>235 days</td>
<td>365 days</td>
</tr>
<tr>
<td><strong>Intercepted volume</strong></td>
<td>11%</td>
<td>67%</td>
</tr>
<tr>
<td><strong>Water losses</strong></td>
<td>4%</td>
<td>6%</td>
</tr>
<tr>
<td><strong>Representativity of sampling strategy</strong></td>
<td>80%</td>
<td>94%</td>
</tr>
</tbody>
</table>
Hydraulic Residential Time strongly depends on watershed hydrological response:
- short in winter (less than 1 day)
- longer during other seasons (between 2 and 100 days)
No decrease of pesticides application during the monitoring periods.
Pesticides results

76 molecules applied every year (1.71kg of active molecules per ha)

→ About 64 analysed (84%):
  → 27 non detected; 38 molecules detected > LQ
  → 6 non applied but detected such as atrazine

Annual dynamic of pesticides transfer following application
Pesticides exportation from drained area

In average, about 1.5g of exported pesticides per hectare, corresponding to less than 0.1% of applied amount at crop field in subsurface drainage context.

Distributed as more than 70% for herbicides (including some metabolites), and secondly fungicides.
Pesticides removal efficiency within the artificial wetland

**Concentration**
Reduction of peaks, and concentrations thank to the wetland (Sum<0.5µg/L)

**Fluxes**
-118g/year

**Internal efficiency**
35% in average

**Global efficiency**
22% in average

Depending on water interception strategy
Driven factors for pesticides removal efficiency?

HIGH VARIABILITY ACCORDING TO MOLECULES

Any clear evidence of efficiency depending on pesticides properties

*Strong sorption, low DT50 seem to increase efficiency*

BUT

Season (temperature), pH and HRT should also have a real influence
### Pesticides removal efficiency ranking

<table>
<thead>
<tr>
<th>Inefficient</th>
<th>10 → 20%</th>
<th>20 → 40%</th>
<th>40 → 60%</th>
<th>60 → 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesotrione</td>
<td>Cyproconazole</td>
<td>Clopyralid</td>
<td>Clomazone</td>
<td>2,4-D</td>
</tr>
<tr>
<td>Imazamox</td>
<td>Imidaclopride</td>
<td>Bentazone</td>
<td>Aclonifen</td>
<td>Benoxacor</td>
</tr>
<tr>
<td>Chlortoluron</td>
<td>Atrazine déséthyl</td>
<td>Metamitrone</td>
<td>Dimethenamide</td>
<td>Chlorméquat</td>
</tr>
<tr>
<td>Ethofumesate</td>
<td>Mesosulfuron mtl</td>
<td>Chloridazon</td>
<td>Atrazine</td>
<td>Triflusulfuron mtl</td>
</tr>
<tr>
<td>Fluroxypyr</td>
<td>Isoproturon</td>
<td>Florasulam</td>
<td>S-metolachlor</td>
<td>Ethephon</td>
</tr>
<tr>
<td>2,4-MCPA</td>
<td>AMPA</td>
<td>Boscalid</td>
<td>Azoxystrobine</td>
<td>Napropamide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dimetachlore</td>
<td>Diflufenican</td>
<td>Tebuconazole</td>
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<tr>
<td></td>
<td></td>
<td>Nicosulfuron</td>
<td>Lenacile</td>
<td>Epoxyconazole</td>
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<td></td>
<td></td>
<td>Propyzamide</td>
<td>Glyphosate</td>
<td>Pendimethaline</td>
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<td></td>
<td></td>
<td></td>
<td>Propiconazole</td>
<td>Fluoxastrobine</td>
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<td></td>
<td></td>
<td></td>
<td>Quinmerac</td>
<td>Métazachlor</td>
</tr>
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</table>

Should these results influencing farmers’ pesticides choices and practices?
Take Home Message

The 3 years monitoring of artificial wetland showed
1) High potentiel for Pesticides removal
2) High variability of removal efficiency according to pesticides
¡It is not a 100% warranty solution, important to accept variability
3) The crucial knwoledge of pollutant water dynamic upstream (hydrological diagnosis)
4) Water and Hydraulic residential time management influence deeply the removal efficiency: IN STREAM strategy should be recommended
5) Still question about pesticide accumulations and metabolites???

The monitoring provides a set of data, useful for designing the future artificial wetland according to the water quality objective
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Thank you for your attention