Effectiveness of Vegetative Buffer Strips for reducing Pesticide and Nitrogen transfers to water streams

The uptake water supply of Coulonage – St Hippolyte (SW France) : a case study

Odile Leccia Phelpin

May 30. 2017
Concerns

Non point source pollution in an 4,000 km² agricultural watershed:

How to reduce diffuse pollution from agricultural plots to the rivers?

Can filter strip efficiently reduce pollution?

-> Long-term impacts of Vegetative Filter Strips (VFS) practices on surface water quality have been tested within scenarios.
Trapping pollutants in surface runoff with VFS

A VFS is a strip of dense vegetation intended to intercept runoff from upslope pollutant sources and to filter it

- reduces overland flow velocity
- increases infiltration reducing both the runoff volume and non-particulate contaminant

Identified as the best cost-efficient BMPs VFS is mainly implemented around the farming plots
GenLU2 - SWAT modeling framework

-> all required input data for agro-hydrological modeling are processed though Genlu2
VFS in the SWAT model

The Vegetative Filter Strip (VFS) area is implemented into the SWAT model as a sub-routine which simulates the reduction of sediments, nutrients, pesticides and bacteria trapped into the vegetative area.

\[
\text{DAFS}_{\text{ratio1}} = \frac{\text{DAFS}_{\text{ratio}} (1 - \text{DF}_{\text{con}})}{0.9}
\]

\[
\text{DAFS}_{\text{ratio2}} = \frac{\text{DAFS}_{\text{ratio}} (1 - \text{CF}_{\text{frac}}) \text{DF}_{\text{con}}}{0.1}
\]

Source: SWAT theoretical documentation
Selection and spatialization

The land is discretized into unique Combinations of soil and landuse in each SubBasin (SB)

-> the Hydrological Response Unit (HRU)

HRU are spatially non explicit

The closest HRUs to the stream have been selected automatically within a 25m buffer

The selection done by a GIS routine has been adjusted manually

-> 551 HRUs selected
Calibration – validation of the SWAT-GENLU Model

TO THE FOUR GAUGING STATIONS

- 2 methods: PEST and SWAT-CUP

- Nash-Sutcliffe Efficiency ranking:
  1. Charente river at Beillant (80 % - idem)
  2. Seugne tributary at la Lijardière (70 % - 60%)
  3. Né tributary at Ars (60 - 55%)
  4. Antenne tributary at Antenne (50 % - id.)

Conclusion:
Correct stream flow calibrations
Higher uncertainty for Antenne location
2 methods used:
- PEST
- SWAT-CUP

Calibration – validation at each gauging station

Charente river 80 % - idem
Seugne tributary 70 % - 60%

Antenne tributary: 50 % - id.
Né tributary: 60 - 55%
Vegetative Filter Strips scenarios: 6 widths tested for each of the Herb scenarios
Simulating pesticide loss Response under several Herb Scenarios

SB # 41 is representative of the landuse accounting for 61 % of herb integration (21 ha)

The location on this SB is also important for water resource managers
Important climate inter annual variability
A MAJOR CONTROL FACTOR IN TRANSPORT

Climate is finely modelled with 11 institutional stations, and 6 climate parameters. Daily time series are affected to each SB in regards of the shortest distance. Each scenario has the same climate data set.

Variability of scenarios $= f$(agricultural practices)
### Scenario efficiency

- Transport reduction for the most soluble pesticides and for nitrate
- Most efficient scenarios are VFS « Herb » scenarios

<table>
<thead>
<tr>
<th>NS</th>
<th>Non significatif</th>
<th>SDCI-4</th>
<th>SDCI-5</th>
<th>SDCI-6</th>
<th>SREF-3</th>
<th>BIO-1</th>
<th>BIO-2</th>
<th>BIO-3</th>
<th>BIO-4</th>
<th>BIO-5</th>
<th>BIO-6</th>
<th>BIO-7</th>
<th>DEPP</th>
<th>HERB-1</th>
<th>HERB-1 10m</th>
<th>HERB-1 15m</th>
<th>HERB-1 20m</th>
<th>HERB-1 25m</th>
<th>HERB-1 30m</th>
<th>HERB-1 5m</th>
<th>HERB-2</th>
<th>HERB-2 10m</th>
<th>HERB-2 15m</th>
<th>HERB-2 20m</th>
<th>HERB-2 25m</th>
<th>HERB-2 30m</th>
<th>HERB-2 5m</th>
<th>HERB-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>++</td>
<td>(25 %; 50 %]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+</td>
<td>[5 %; 25 %]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>=</td>
<td>[-5 %; 5 %]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>[-25 %; 5 %]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--</td>
<td>[-50 %; -25 %]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;= -50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;= -25%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>=</td>
<td>[-5 %; 5 %]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;= -50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Aclonifen | Chlorpyriphos-ethyl | Glyphosate | Isoproturon | Mancozébe | MCPA, 2-4 | Metaldehyde | Smetolachlore | Tebuconazole | Toutes molécules | NO3

| Scenario | Aclonifen | Chlorpyriphos-ethyl | Glyphosate | Isoproturon | Mancozébe | MCPA, 2-4 | Metaldehyde | Smetolachlore | Tebuconazole | Toutes molécules | NO3 |
|----------|-----------|---------------------|------------|-------------|-----------|------------|-------------|--------------|---------------|----------------|------------------|-----|
| SREF-3   | 0,07      | 0,01                | 0,14       | 0,21        | 0,04      | 0,12       | 0,17        | 2,74         | 0,02          | 3,51           | 18,1 |

-- Non significatif

++ {25 %; 50 %]  
+ {5 %; 25 %]  
= {-5 %; 5 %]  
- [-25 %; 5 %]  
-- [-50 %; -25 %]  
>= -50 %  
--- >= -50 %  
---
Discussion, limits of the method

Because HRUs are not spatially based

>> Selection bias: All portions of territories along the streams could not be entirely selected
- consequently VFS benefits are underestimated

>> The SWAT VFS sub-routine is based on conceptual basis
- Needs to be adapted
Conclusion

• Despite the current limits, simulation with SWAT-GENLU show pertinence for decision makers to target mitigation measures on the most contributive areas
• Widening filter strips do not drive in all cases to a better environmental efficiency (decreasing marginal benefits)

Perspectives

• A complete revamp SWATGrid of the SWAT model has been released but too roughly tested so far and anyhow is not suitable to large watersheds (Pignotti et al. 2017)
• Further developments of the VFS routine within the SWAT model
• New scenarios planned to integrate climate change issues
Thank you for your attention!

Questions?