# REMOVAL OF PESTICIDE MIXTURES IN A STORMWATER WETLAND COLLECTING RUNOFF FROM A VINEYARD CATCHMENT

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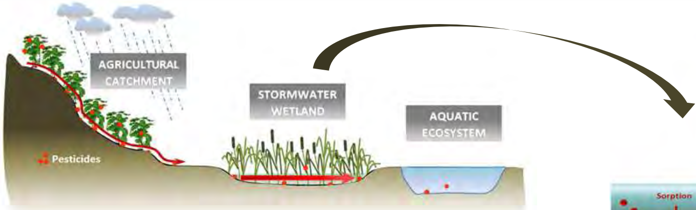
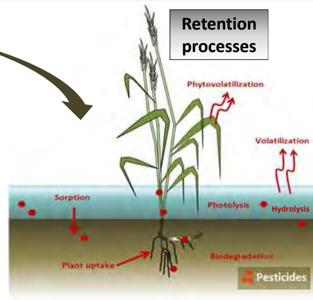
## INTRODUCTION

**Surface runoff is a major process of contaminants transfer** as a significant portion of pesticides applied to agricultural fields can move into aquatic ecosystems during rainfall-runoff events. **Buffer zones, such as wetlands, can collect contaminated runoff from agricultural catchments and have intrinsic physical, chemical and biological retention and removal processes useful for mitigating mixtures of pesticides**, and thus limiting the contamination of aquatic ecosystems.




**The objective of the present study was to assess the ability of a stormwater wetland to remove a mixture of pesticides in runoff from a vineyard catchment during the period of pesticide application (April to September 2009).** In particular, we evaluated the relationships between pesticide removal and changes of hydrochemical characteristics and flow conditions. Besides, the ability of the stormwater wetland to remove pesticide mixtures in runoff was compared during two periods of pesticide application (April to June 2009 and 2010).

## MATERIAL AND METHODS

### Study site

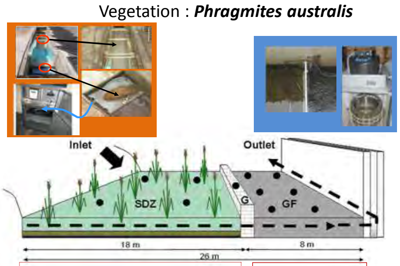
**VINEYARD CATCHMENT**

Location : **Rouffach, Alsace, France**
Area : **42.7 ha**
**67 %** vineyard
**Dry catchment**
Mean slope : **15 %**
$P_{yearly}$ : **600 mm**
Runoff coeff. : **0.2 – 1.2 %**

**WETLAND**

Surface: **320 m²**
Volume : **1500 m³**
HRT : **8-12 hs**
Time between 2 runoff events : **10 d**
Vegetation : ***Phragmites australis***


**OUTLET = STORMWATER WETLAND**




Sediment deposition zone | Gravel filter

### Measurements and analyses

**Meteorological data**
- Rainfall amounts
- solar radiation

**Continuous discharge measurements INLET / OUTLET**

**Pesticide analysis** (17 molecules) — LC-MS
- Runoff water
- Wetland water column
- Suspended solids
- Wetland sediments

**Vegetation cover**

**INLET / OUTLET estimates of pesticide mass loadings**

**Hydrochemistry**
- Carbon
- Physico-chemical parameters
- Nutrients
- Cations / Anions
- Metals

**Pesticide removal and retention processes**

## RESULTS / DISCUSSION

### April to September 2009

- **Hydrochemical variability in the stormwater wetland**

→ *Changes of the hydrochemical conditions in the stormwater wetland between April and September 2009 (fig. 1).*

**OXIC** *during spring*
Vegetation cover 10 %

**ANOXIC** *during summer*
Vegetation cover 90 %

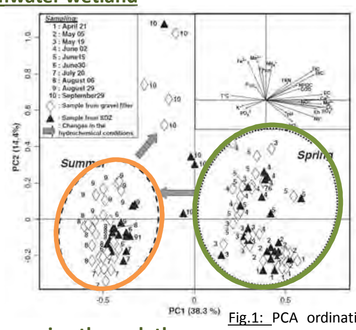



Fig.1: PCA ordination plot of hydrochemical characteristics of water samples collected in the stormwater wetland

- **Mass balances of pesticides and solids passing through the wetland**

Table 1: Fluxes of dissolved pesticides, suspended solids, suspended solids-associated pesticides and dissolved organic carbon.

| | | Spring (Apr. 06 – June 15) | | | Summer (June 15 – Sept. 29) | | | |
|---|---|---|---|---|---|---|---|---|
| | | Inlet | Outlet | R [%] | Inlet | Outlet | R [%] | |
| Dissolved pesticides | [mg] | 1291 | 339 | 72 | 6819 | 2181 | 73 | → No seasonal changes |
| Suspended-solids associated pesticides | [mg] | 2.07 | n.d. | n.d. | 196 | n.d. | n.d. | → Low Kd values |
| Suspended solids | [kg] | 207 | 3 | 99 | 739 | 99 | 88 | → High trapping efficiency |
| Dissolved organic carbon | [kg] | 3.6 | 5.8 | -34 | 6.1 | 7.1 | -18 | → Possible transfer as DOC-associated pesticides |

### Comparison between April to June 2009 and 2010

Table 2: Pesticide concentrations at the inlet and at the outlet of the stormwater wetland in 2009 and 2010.

| Compound | 2009 Inlet (n=13) [µg.L⁻¹] | 2009 Outlet (n=19) [µg.L⁻¹] | 2009 $R_C$ % | 2010 Inlet (n=19) [µg.L⁻¹] | 2010 Outlet (n=19) [µg.L⁻¹] | 2010 $R_C$ % |
|---|---|---|---|---|---|---|
| **Glyphosate** | 4.15 (0.30 - 11.00) | 0.12 (n.d. - 0.70) | **97** | 30.38 (n.d. - 110) | 0.29 (n.d. - 1.70) | **99** |
| ***AMPA*** | 1.21 (0.20 - 2.30) | 0.41 (n.d. - 0.70) | **66** | 5.67 (n.d. - 19.00) | 0,34 (n.d. - 0.90) | **94** |
| **Kresoxim methyl** | 0.03 (n.d. - 0.4) | n.d. | **100** | 0.07 (n.d. - 1.20) | <0.01 (n.d. - 0.17) | **89** |
| **Metalaxyl** | 1.15 (n.d. - 5.80) | 0.24 (n.d. - 1.20) | **79** | 0.81 (n.d. - 7.70) | 0.14 (n.d. - 2.00) | **83** |
| **Simazine** | 0.07 (n.d. - 0.18) | 0.02 (n.d. - 0.03) | **71** | <0.01 (n.d. - 0.03) | <0.01 (n.d. - 0.02) | **50** |

→ *Interannual variability of the concentration removal rates*

**Vegetation cover more important in 2010 compared to 2009.**

Rainfall and runoff patterns globally were similar between the April to June 2009 and 2010 periods. **The overall load removal of pesticides was 81% in 2009 and 92% in 2010** (table 3). Despite the larger pesticide load entering the wetland in 2010 compared to that in 2009, the removal ability of the wetland was not affected. However, **load removal rates largely differed according to the individual compounds.**

Table 3: Pesticide mass loadings at the inlet and at the outlet of the stormwater wetland in 2009 and 2010.

| Compound | 2009 Inlet [mg] | 2009 Outlet [mg] | 2009 $R_L$ % | 2010 Inlet [mg] | 2010 Outlet [mg] | 2010 $R_L$ % |
|---|---|---|---|---|---|---|
| Azoxystrobin | 15.1 | 0 | 100 | 0 | 0 | - |
| Cymoxanil | 12.3 | 0 | 100 | 0 | 0 | - |
| Cyprodinil | 10.4 | 0 | 100 | 0 | 0 | - |
| Dimethomorph | 916 | 144 | 84 | 268 | 31.2 | 88 |
| Diuron | 38.4 | 9.1 | 76 | <0.1 | 0 | n.a[1] |
| DCPU | 0 | 0 | - | 0 | 0 | - |
| DCPMU | 1.3 | 0 | 100 | 0 | 0 | - |
| 3,4-dichloroaniline | 0 | 0 | - | 0 | 0 | - |
| Gluphosinate | 108 | 0 | 100 | 0 | 0 | - |
| Glyphosate | 1458 | 128 | 91 | 9983 | 439 | 96 |
| AMPA | 352 | 259 | 26 | 2480 | 467 | 81 |
| Isoxaben | 25.8 | 6.1 | 76 | 53.7 | 7.2 | 87 |
| Kresoxim methyl | 16.7 | 0 | 100 | 57.1 | 13.0 | 77 |
| Metalaxyl | 311 | 80.8 | 74 | 341 | 130 | 62 |
| Simazine | 15.6 | 9.2 | 41 | <0.1 | 0.8 | n.a[1] |
| Terbuthylazine | 14.6 | 0 | 100 | 0 | 0 | - |
| Tetraconazole | 8.4 | 0 | 100 | 0 | 0 | - |
| TOTAL | 3304 | 636 | 81 | 13183 | 1088 | 92 |

[1] n.a. = not assessed due to small loadings resulting from concentrations mainly below the LOQ

The calculation of sedimentation rates revealed that the wetland retained 78% (3.5 kg $d^{-1}$) of the input mass in 2009 and 97% (5.9 kg $d^{-1}$) in 2010. This clearly indicates that **the wetland acts as a sink for particle-laden pesticides**.

## CONCLUSION

- This study demonstrates that stormwater wetlands collecting agricultural runoff have good capacities for retaining, at various flow conditions and loadings, mixtures of pesticides with different physico-chemical properties.
- Our findings also underscore the **pivotal role of vegetation** in retaining moderately hydrophobic compounds.
- Though the use of stormwater wetlands as a management practice targeting pesticide mitigation should not be conceived as a unique solution to treat pesticide runoff, in many cases where other best management practice are not available, the introduction and maintenance of a vegetation cover in stormwater detention systems can be an effective practice to reduce the transfer of contaminants from land into water bodies.

References :

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