Mitigation of Pesticides and Copper in a Stormwater Wetland

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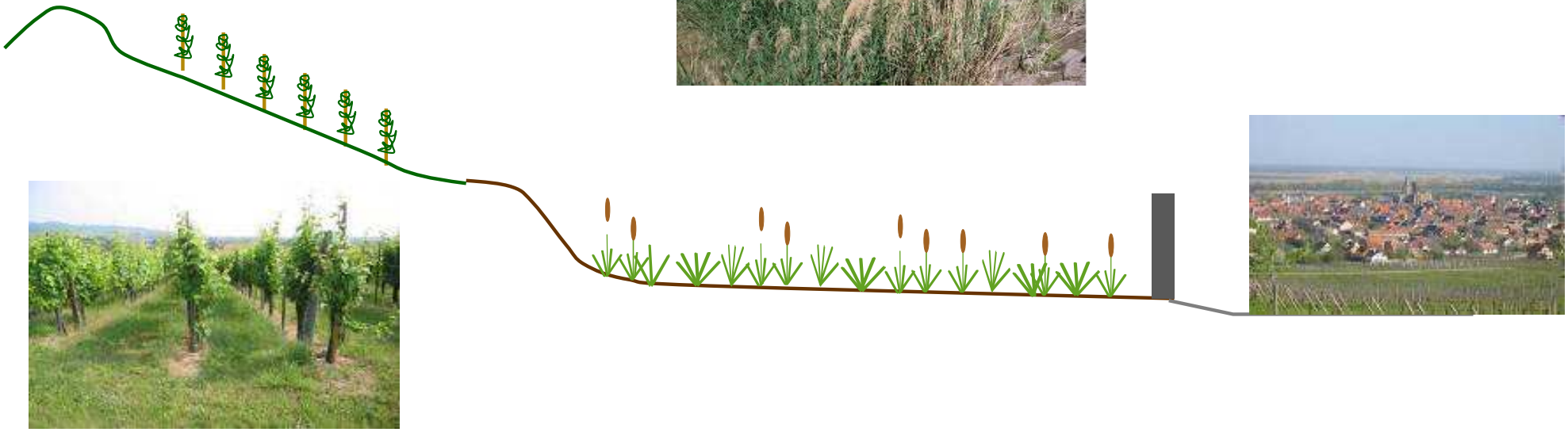
Stormwater wetlands connected to an agricultural catchment

Agricultural/urban catchment

Stormwater wetland

Town



Grégoire et al., (2009) Env. Chem. Let.; Imfeld et al., (2009), Chemosphere

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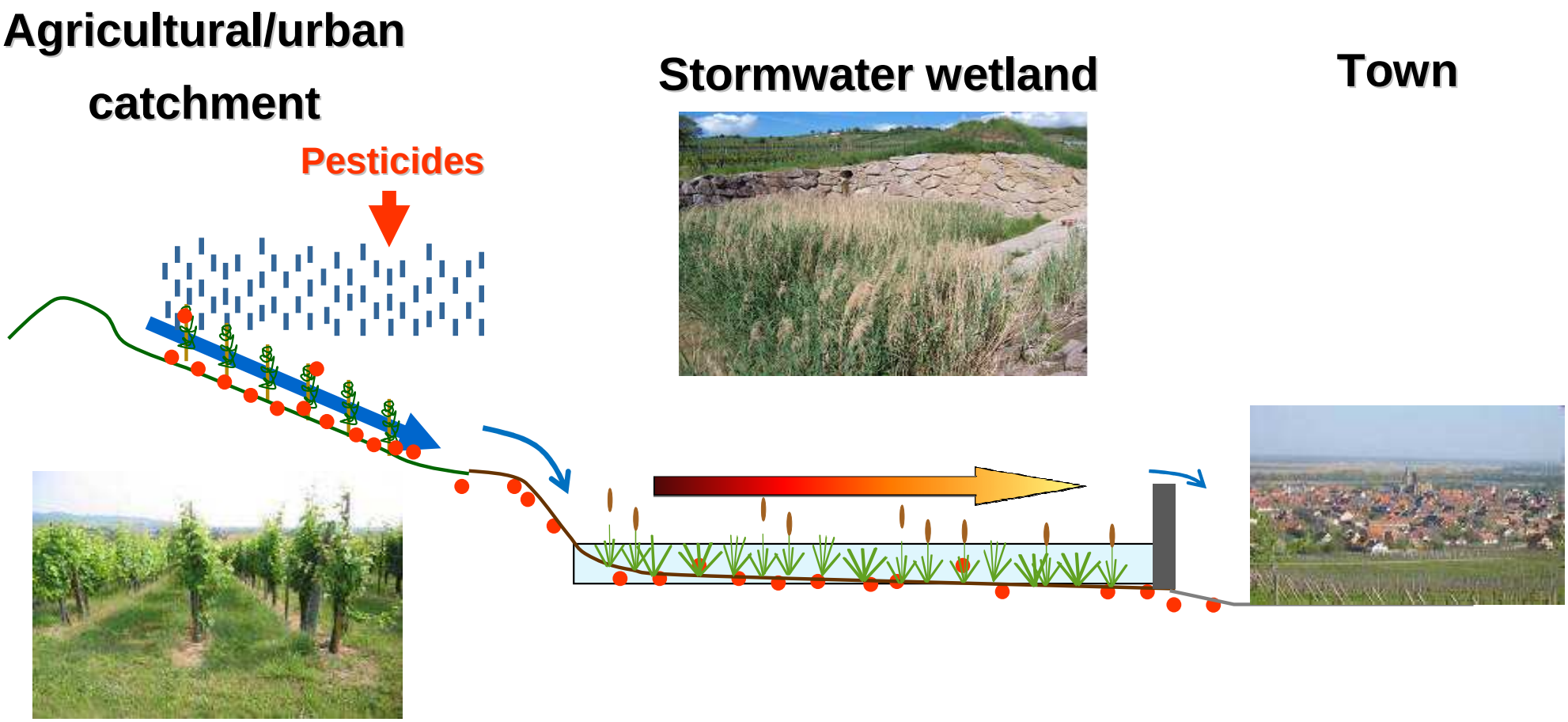

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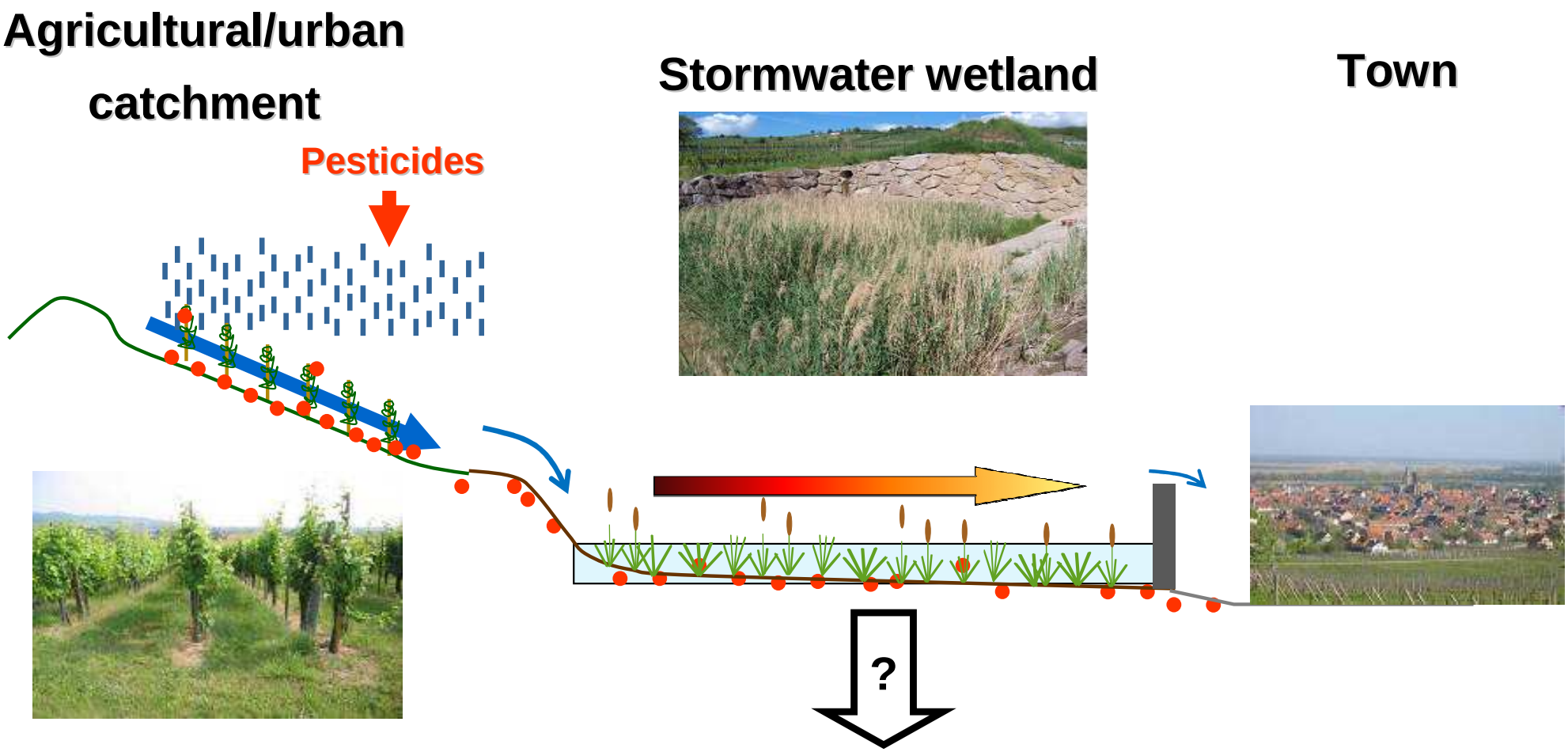

1. What is the capacity of stormwater wetlands to remove pesticide mixtures?
2. How is glyphosate and AMPA transported in stormwater wetlands?
3. How stormwater wetlands retain copper?

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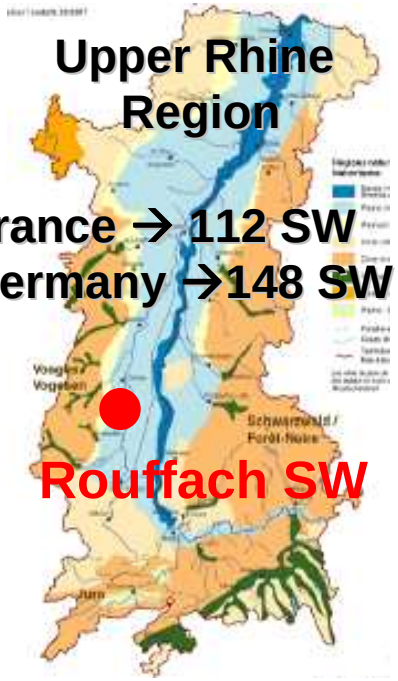
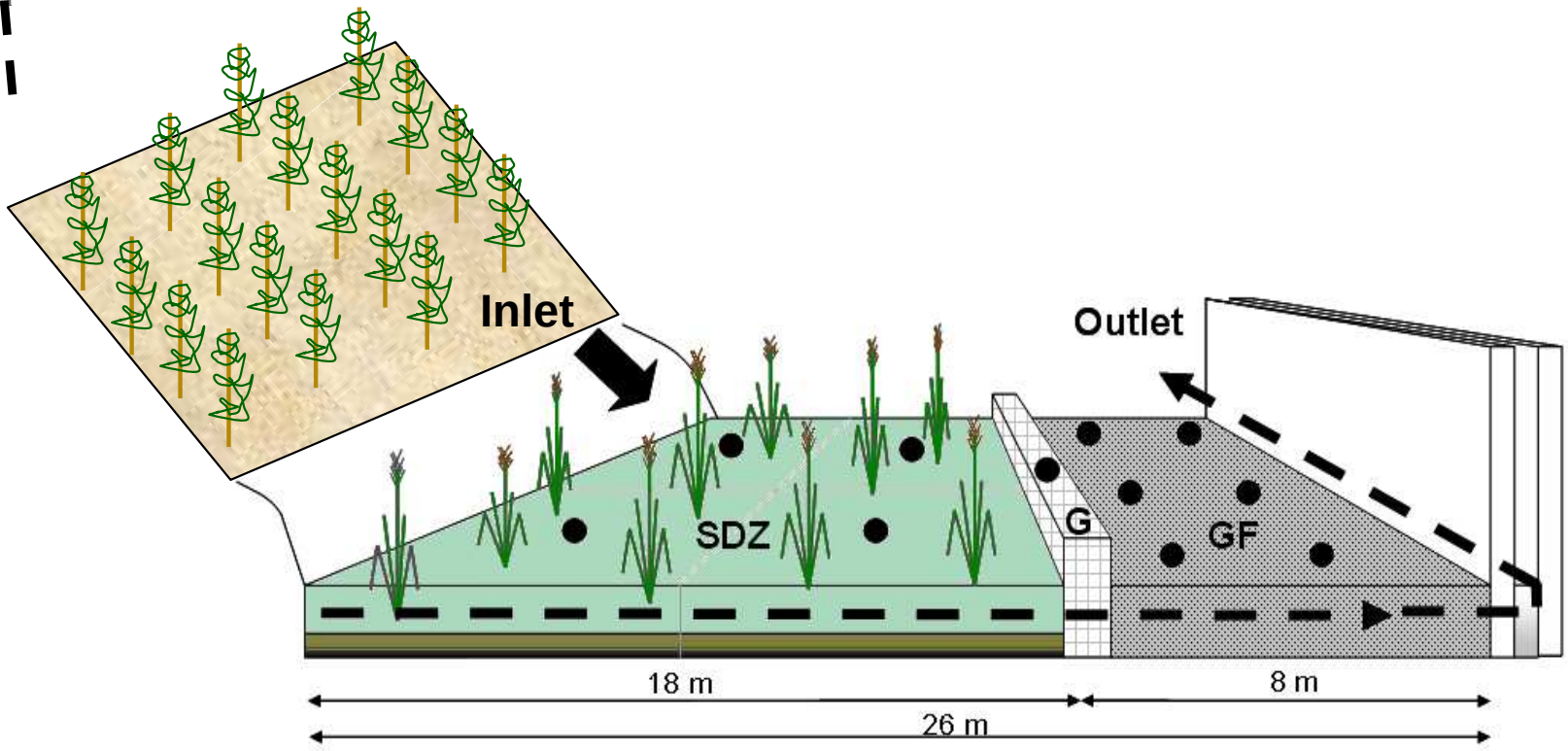
Stormwater wetlands collecting runoff: vineyard catchment

France

Alsace





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Stormwater wetlands collecting runoff: vineyard catchment

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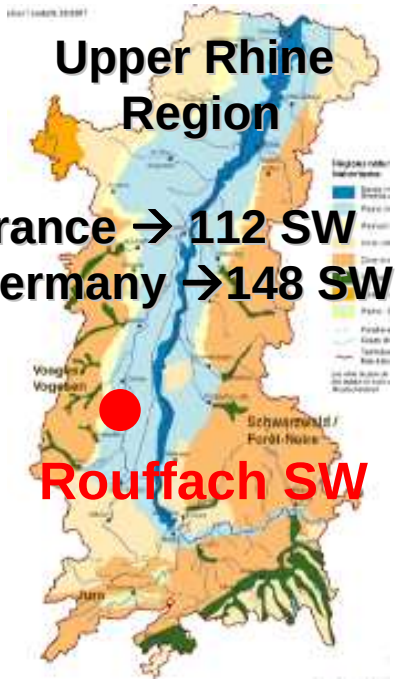


Catchment:

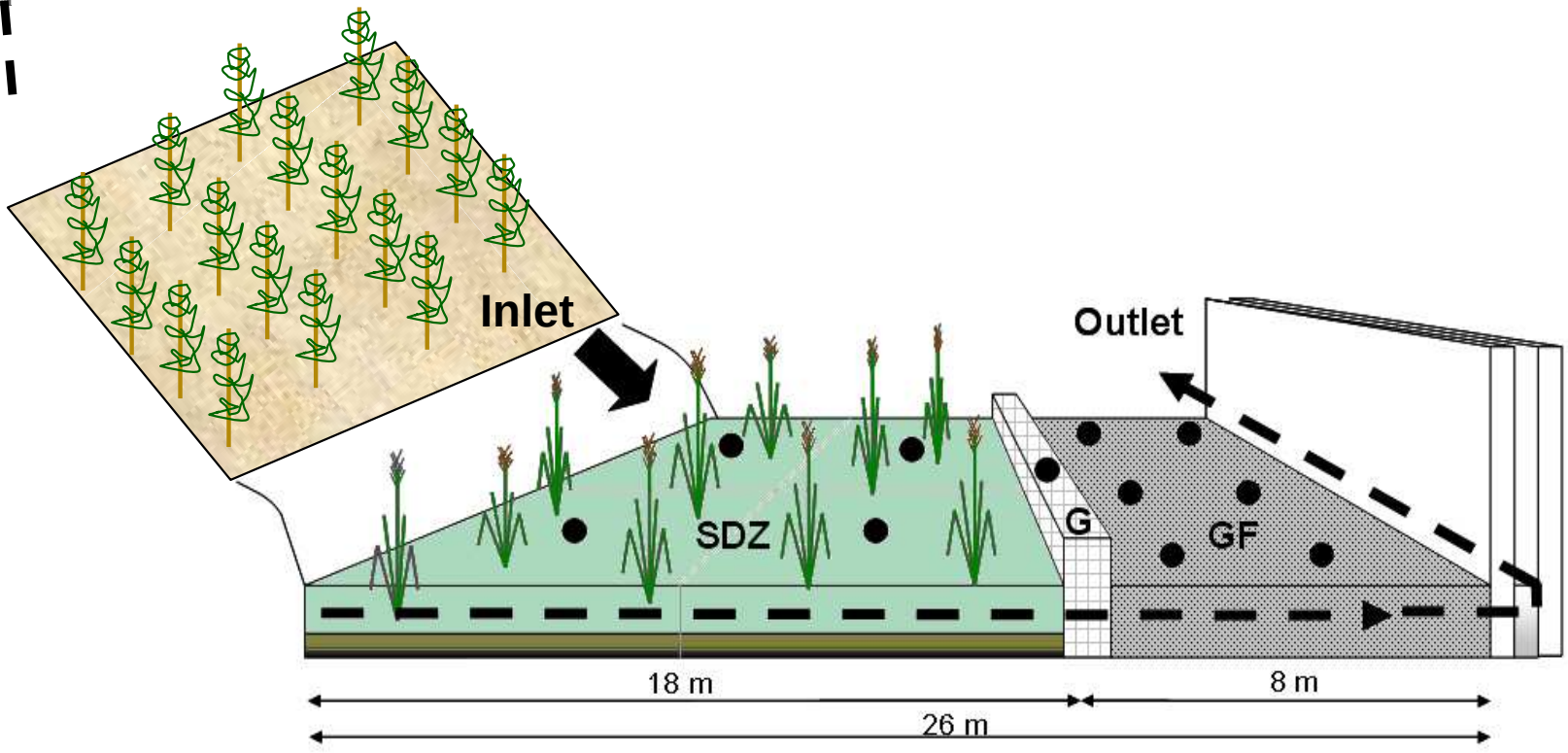
- Area : 42.7 ha
- 67 % vineyard
- Mean slope: 15 %
- P_{yearly} : 600 mm
- Runoff coeff.: 0.2 – 1.2%

- *Pesticide application ≈ 50 kg y^{-1}*

Wetland:

- Surface: 320 m^2
- Volume: 1500 m^3
- HRT: 8-12 hs
- Quiescent period: 10 d
- Vegetation: *Phragmites australis*

- *Pesticide in runoff ≈ 10 g y^{-1}*



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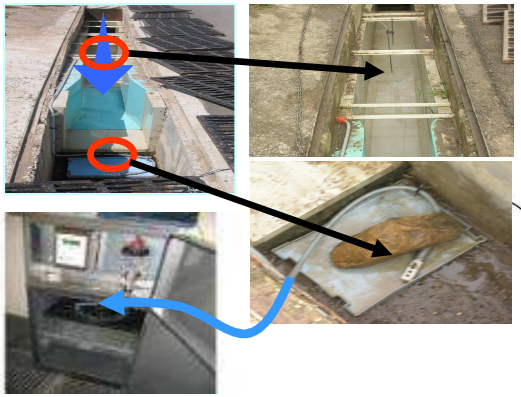
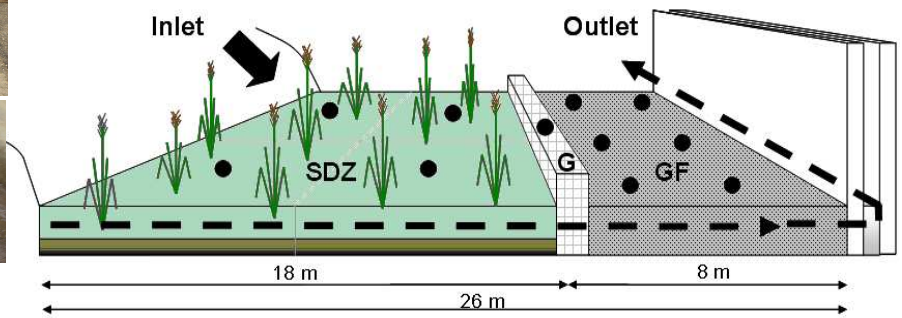
Sampling scheme and analyses



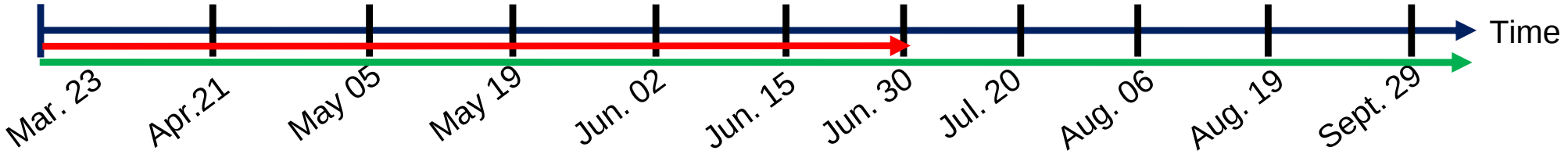


- Discharge measurements
- Hydrochemical parameters
- Pesticide analysis: (+Copper)
  - *Runoff water*
  - *Wetland water column*
  - *Suspended solids*
  - *Wetland sediments*

8 Fungicides
7 Herbicides
1 Insecticide
4 Degradation products

Mass balances ←

=> Sampling campaigns in 2009, 2010 and 2011



Selection of pesticides

Molecule	Log K_{ow}	Aqueous photolysis DT_{50} (pH = 7)	Aqueous hydrolysis DT_{50} (20°C, pH = 7)
	[-]	[day]	[day]
Azoxystrobine	2.50	8.7	stable
Cymoxanil	0.67	1.7	1.1
Cyprodinil	4.00	13.5	stable
Carbendazim	1.48	stable	350
Dimethomorphe	2.68	97	70
Diuron	2.87	43	Stable
DCPU	n.a.	n.a.	n.a.
DCPMU	n.a.	n.a.	n.a.
3.4-dichloroaniline	2.69	0.25	n.a.
Flufenoxuron	4.01	6	267
Gluphosinate	-3.96	n.a.	n.a.
Glyphosate	-3.2	69	Stable
AMPA	-1.63	n.a.	n.a.
Isoxaben	3.94	6	Stable
Kresoxim methyl	3.40	28	34
Metalaxyl	1.65	Stable	106
Pyrimethanile	2.84	Stable	Stable
Simazine	2.30	1.9	96
Terbuthylazine	3.40	Stable	Stable
Tetraconazole	3.56	217	Stable

Fungicides
Herbicides
Insecticides
Degradation products

n.a.: not assessed

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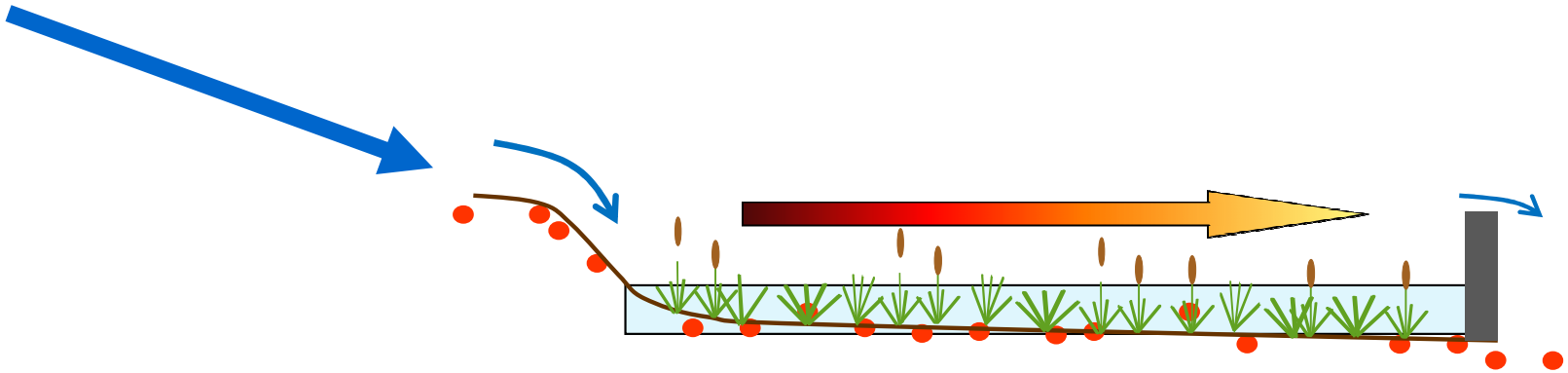
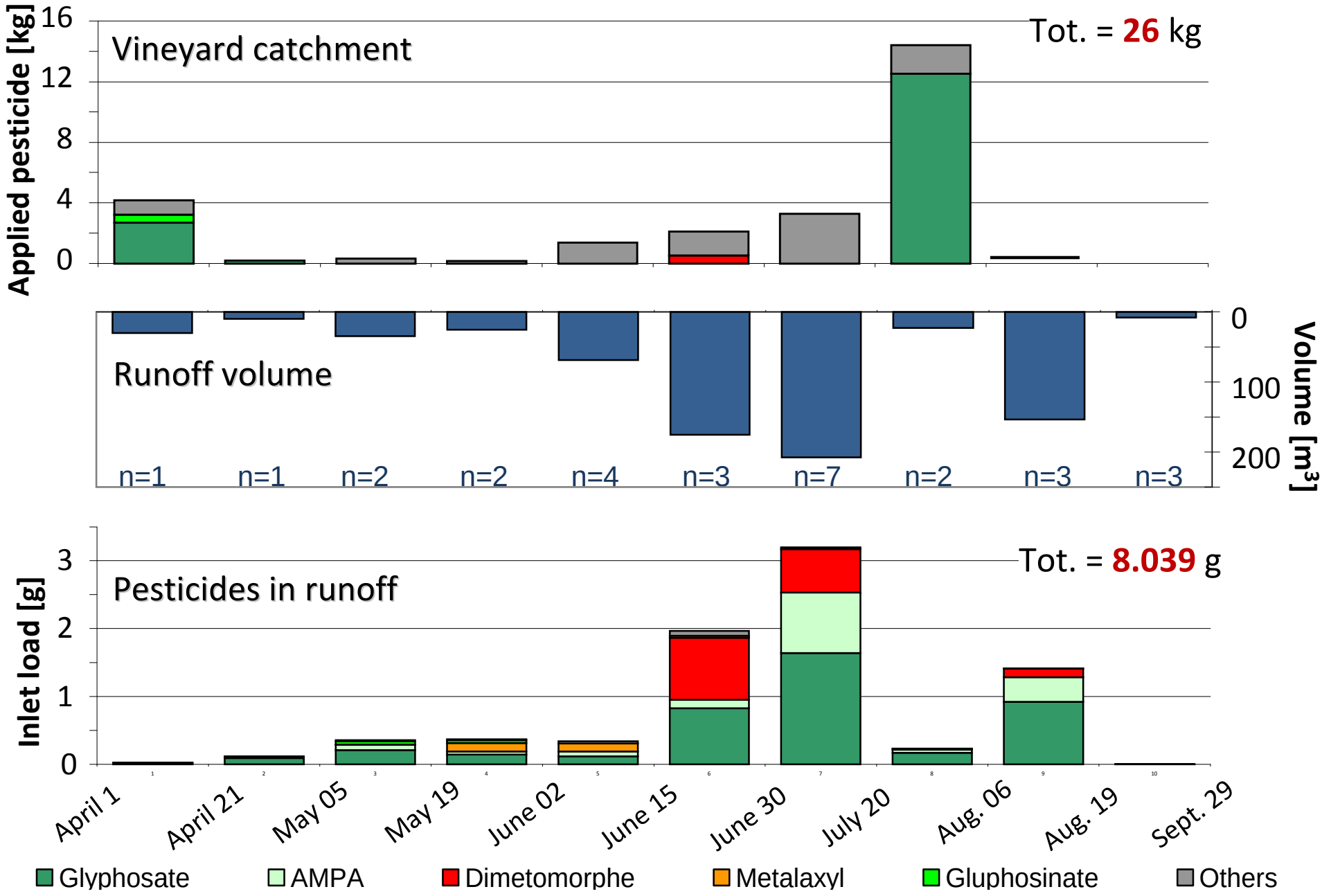


Pesticide mass transfer: vineyard catchement to wetland



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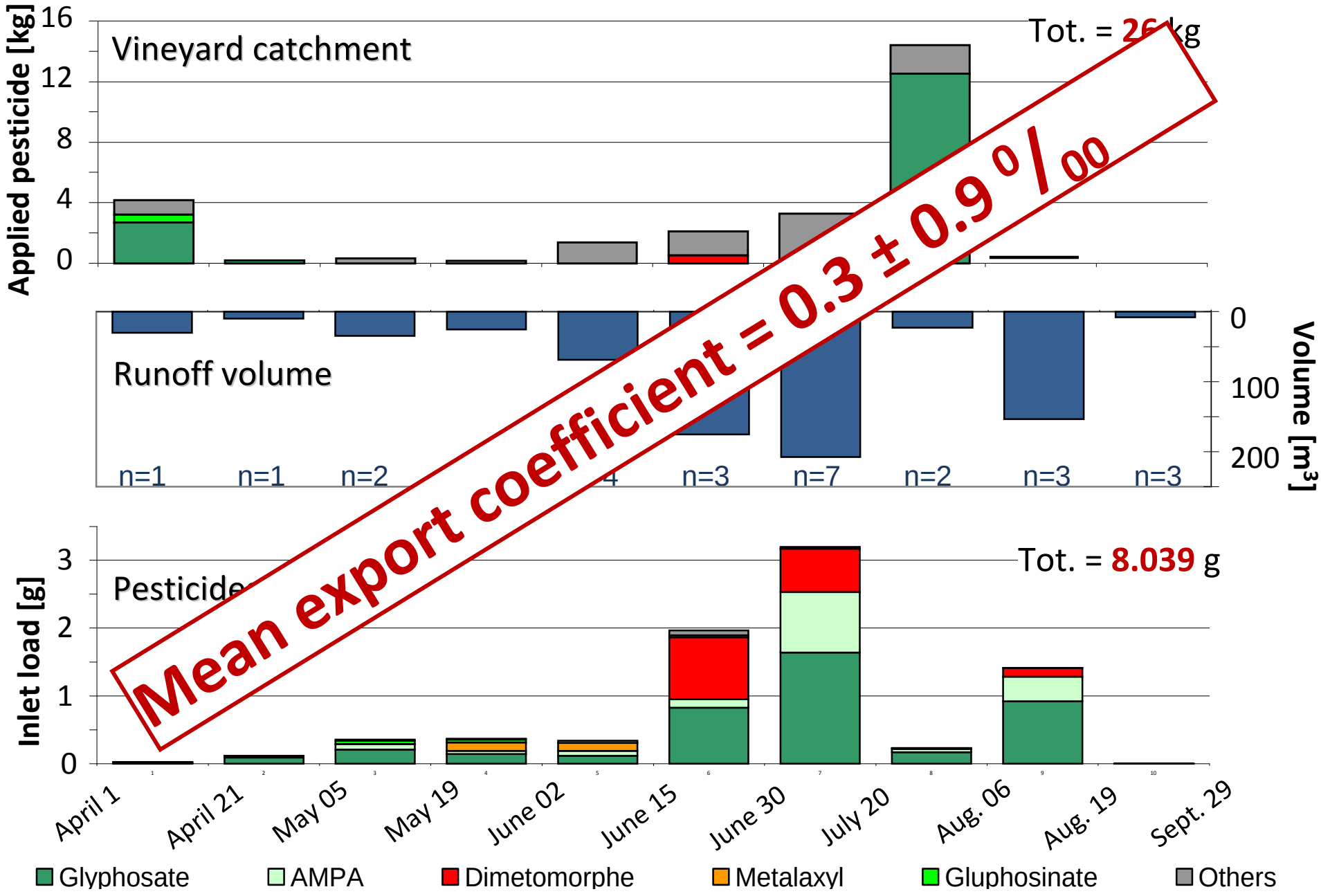

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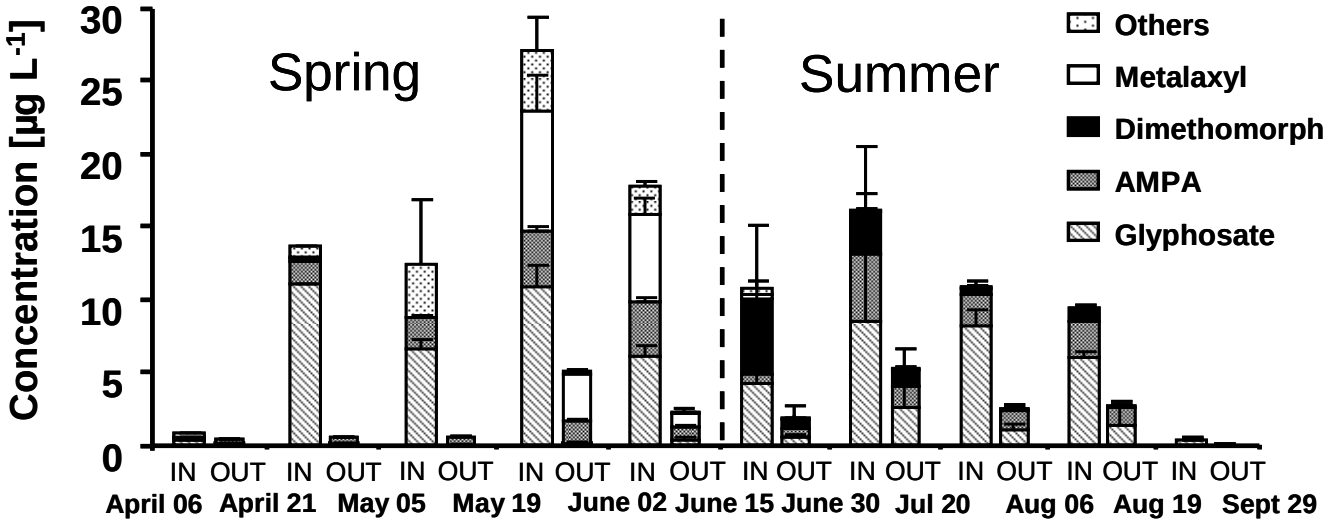
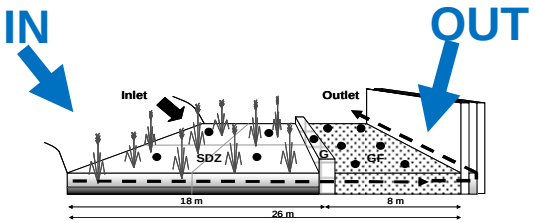
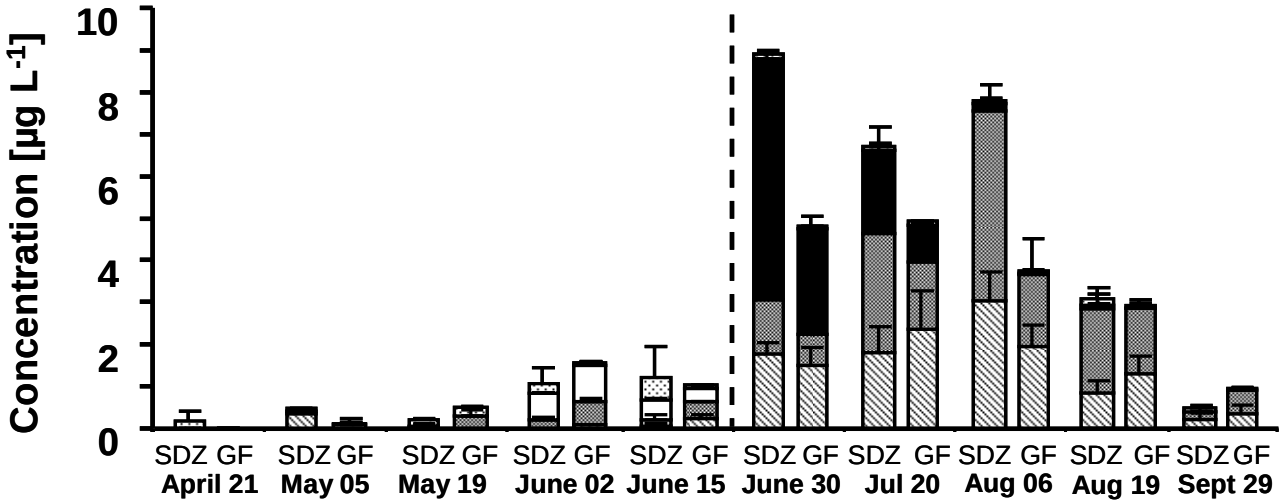
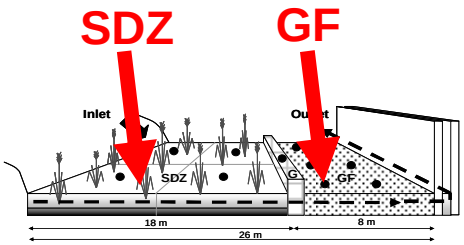
Reduction of pesticide concentration









=> [IN] > [SDZ] > [GF] > [OUT]

=> High temporal variability: lower efficacy in summer

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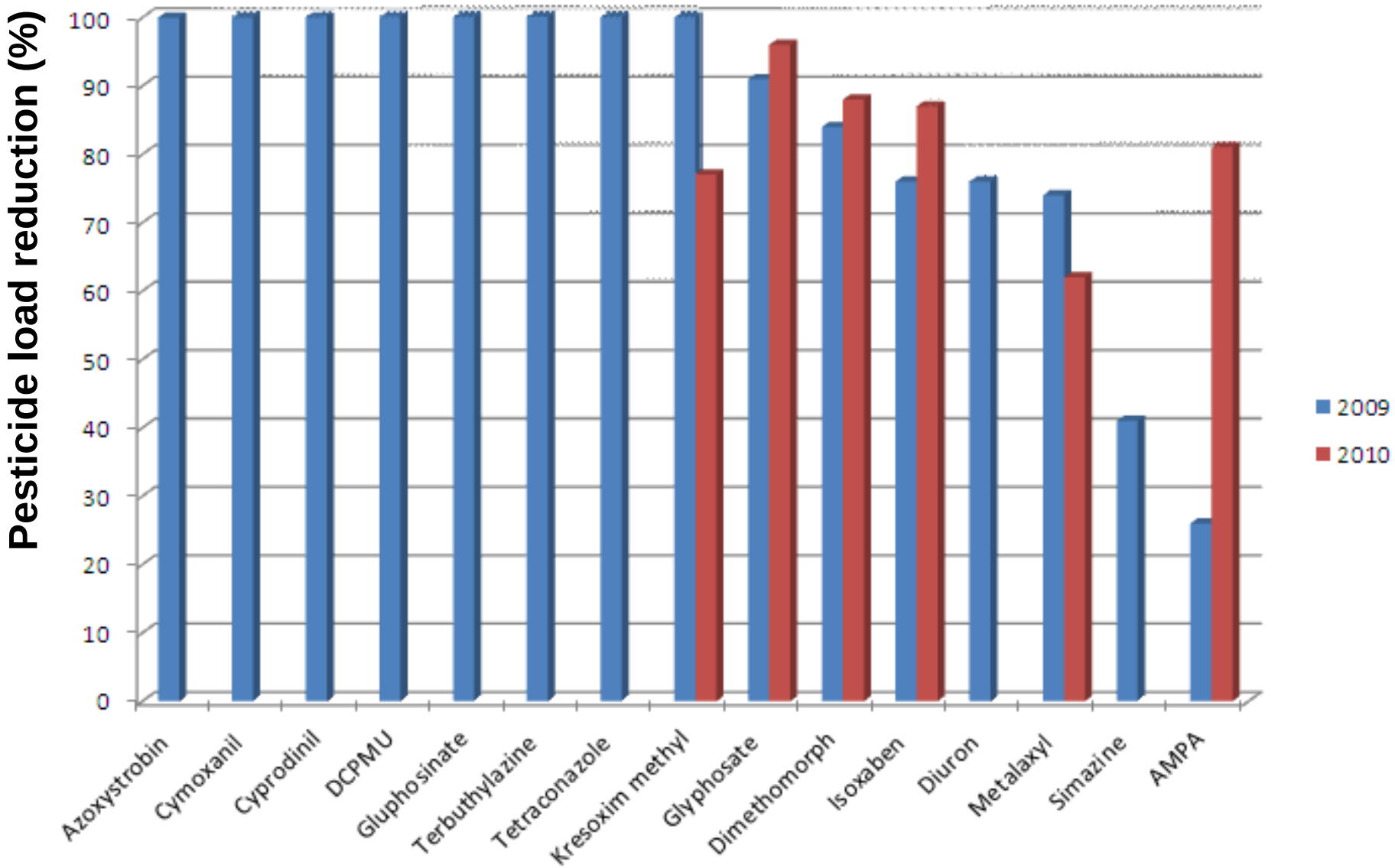
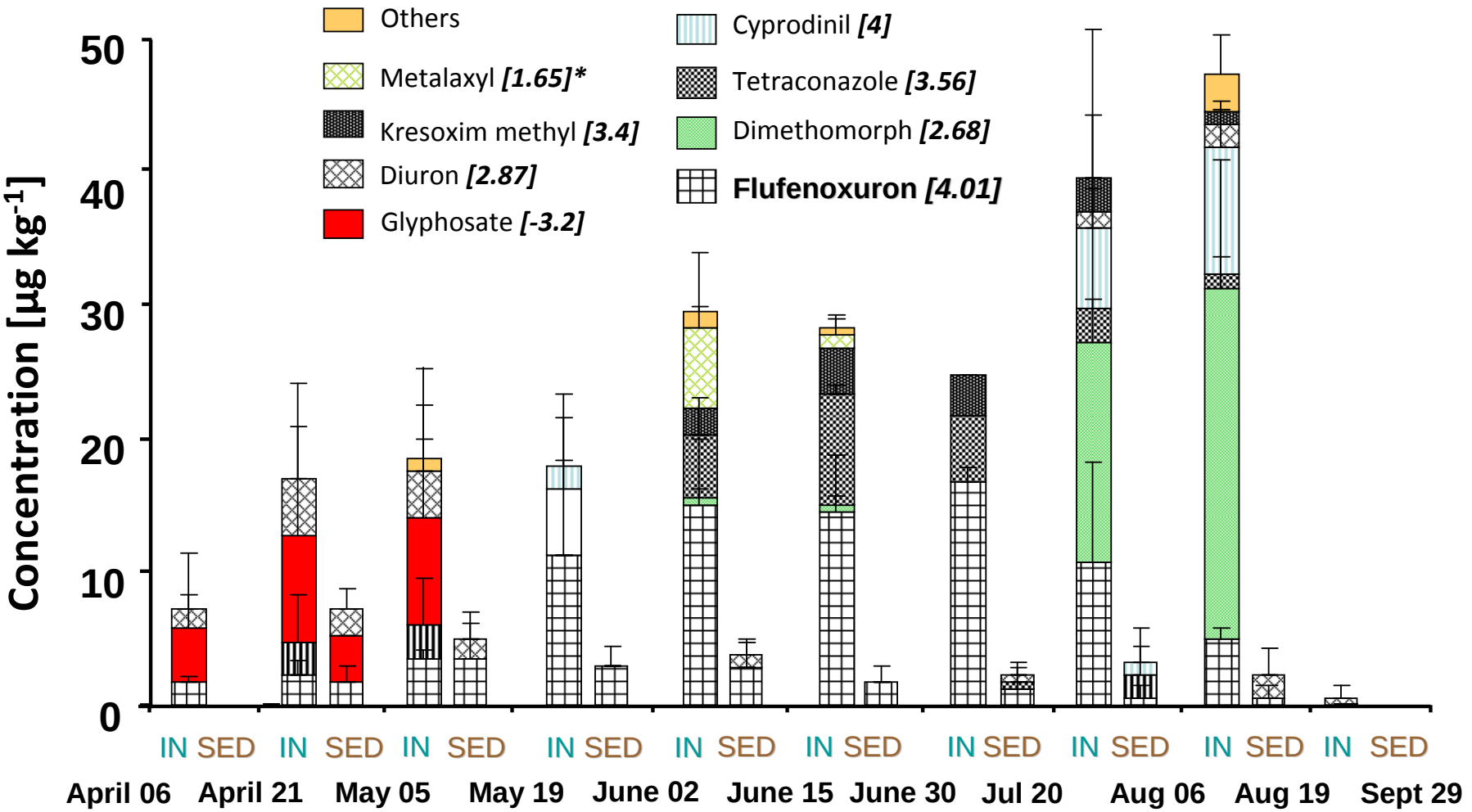
Annual variation of pesticide removal



Maillard et al. (2011) STOTEN, IJEAC (2012)

Pesticide concentrations in wetland sediments

*Log K_{ow} *(PPDB)*



=> No temporal accumulation or persistence of pesticides in the wetland sediments

Maillard et al. (2011) STOTEN, IJEAC (2012)

Seasonal variation of pesticides removal

		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**
Suspended-solids associated pesticides	[mg]	2.07	n.d.	n.d.	196	n.d.	n.d.
Suspended solids	[kg]	207	3	**99**	739	99	**88**
Dissolved organic carbon	[kg]	3.6	5.8	**-34**	6.1	7.1	**-18**

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→ **No seasonal Changes**

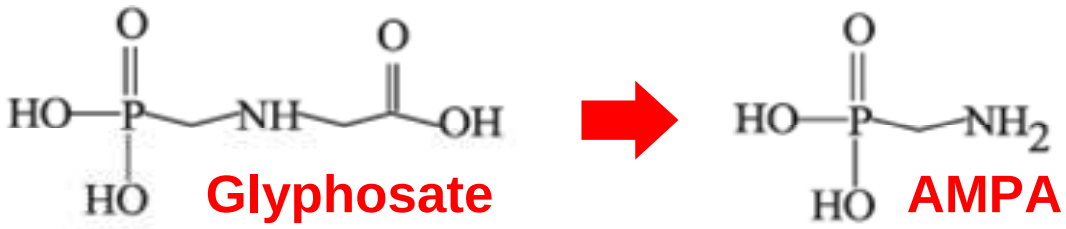
→ **Low Kd values**

→ **High trapping efficiency**

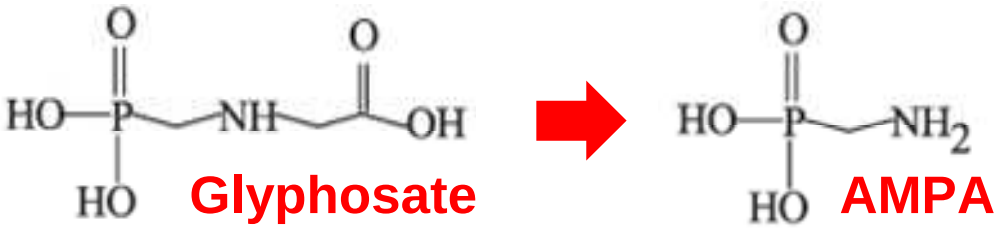
→ **Possible transfer as DOC-associated pesticides**

Maillard et al. (2011) STOTEN, IJEAC (2012)

2. How is glyphosate and AMPA transported in stormwater wetlands?



Transport of glyphosate and AMPA



$$MEL_{gly} = Load(Glyphosate) + \left\{ Load(AMPA) \left[\frac{MW_{gly}}{MW_{AMPA}} \right] \right\}$$

Where

MW_{gly} = molecular weight of glyphosate (0.16907 kg mol^{-1})

MW_{AMPA} = molecular weight of AMPA (0.11104 kg mol^{-1})

Imfeld et al. (2012), Chemosphere

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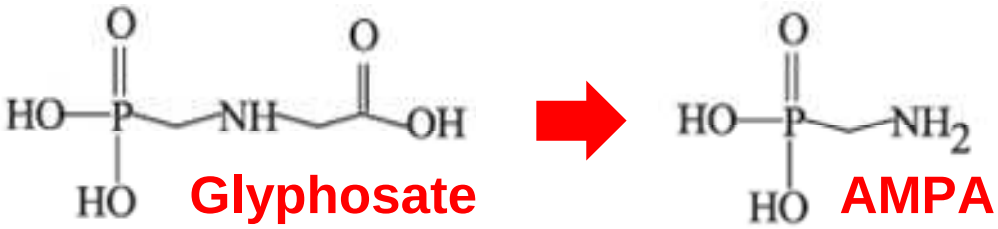

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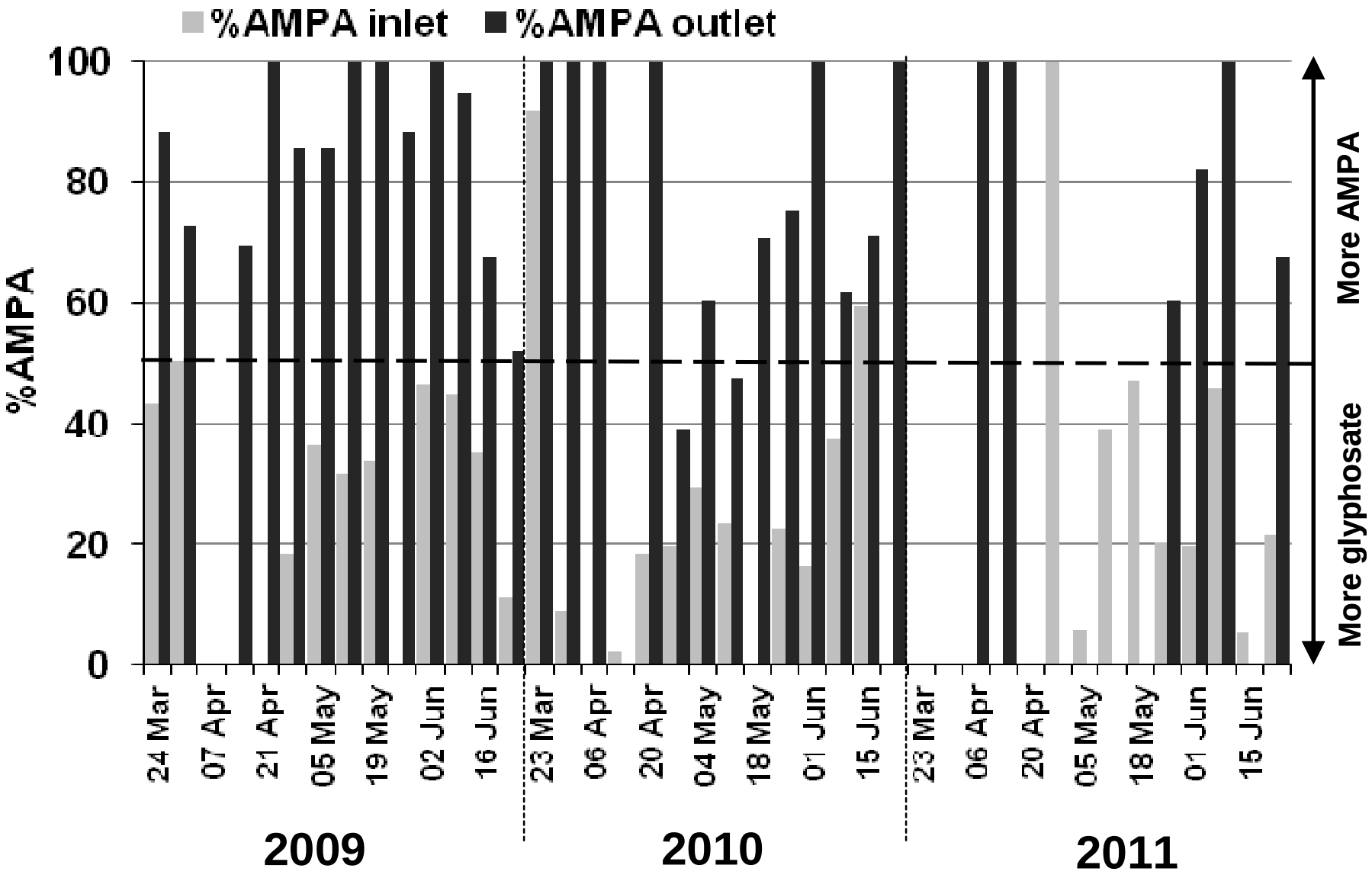
	MEL_{gly} (inflow) [mg]	MEL_{gly} (outflow) [mg]	Removal efficiency [%]	% covered by vegetation
2009	2.38	1.78	75%	<1% - 25%
2010	14.10	12.61	90%	100%
2011	20.79	20.52	99%	100%

Imfeld et al. (2012), Chemosphere

Temporal change of the %AMPA



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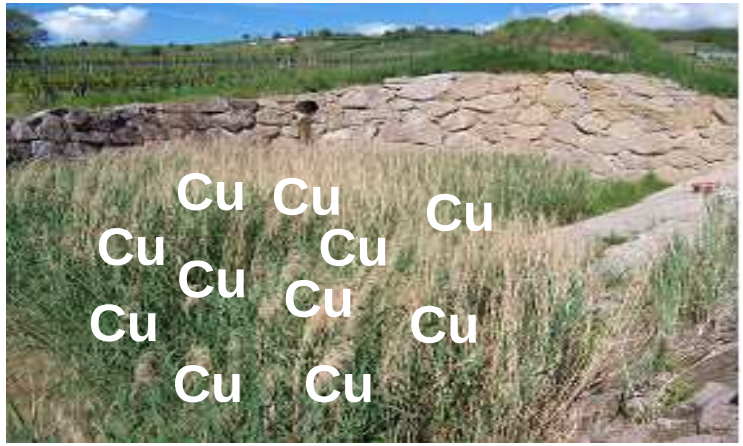
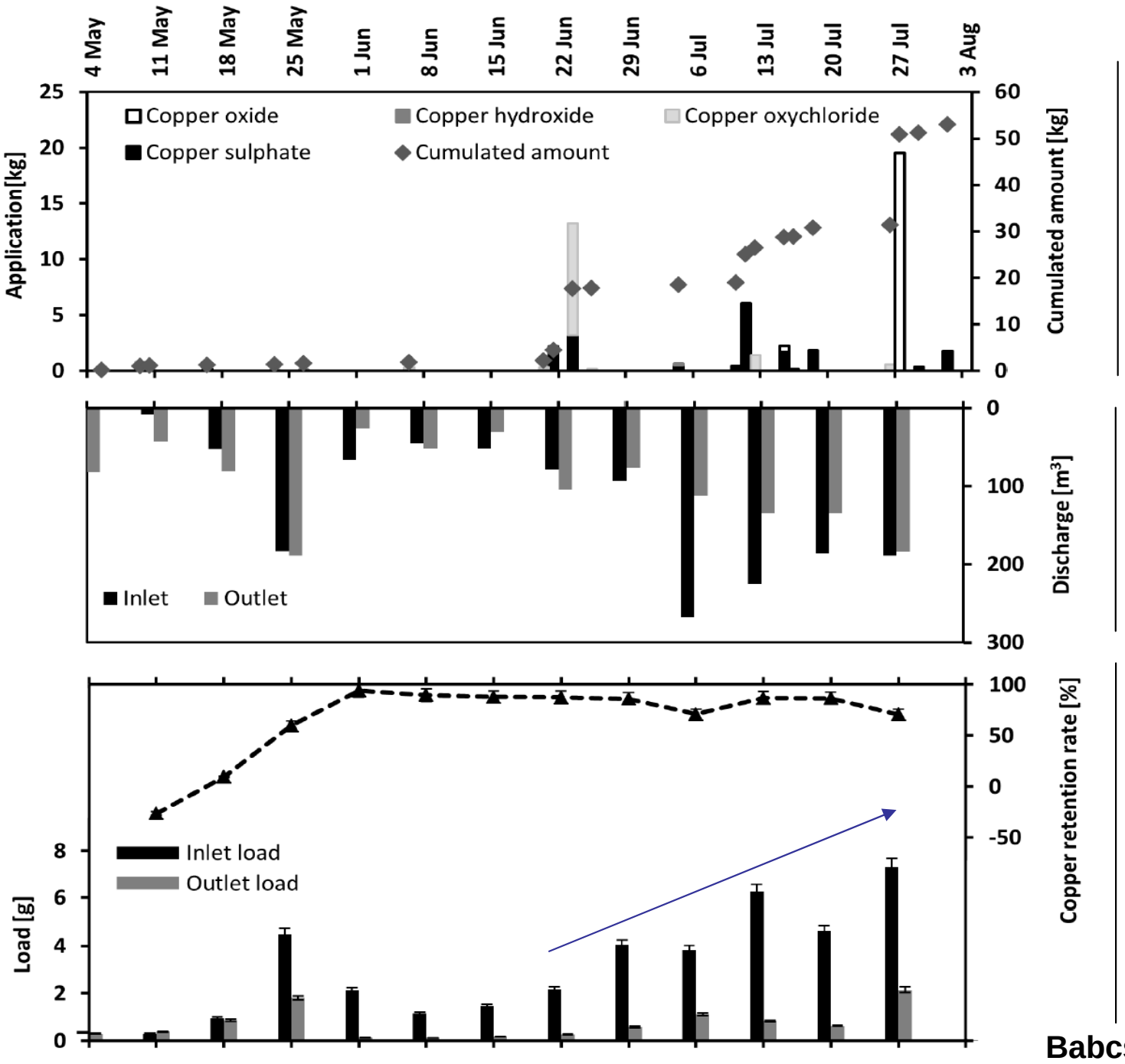
2. How stormwater wetlands retain copper?



Transport of copper in the wetland



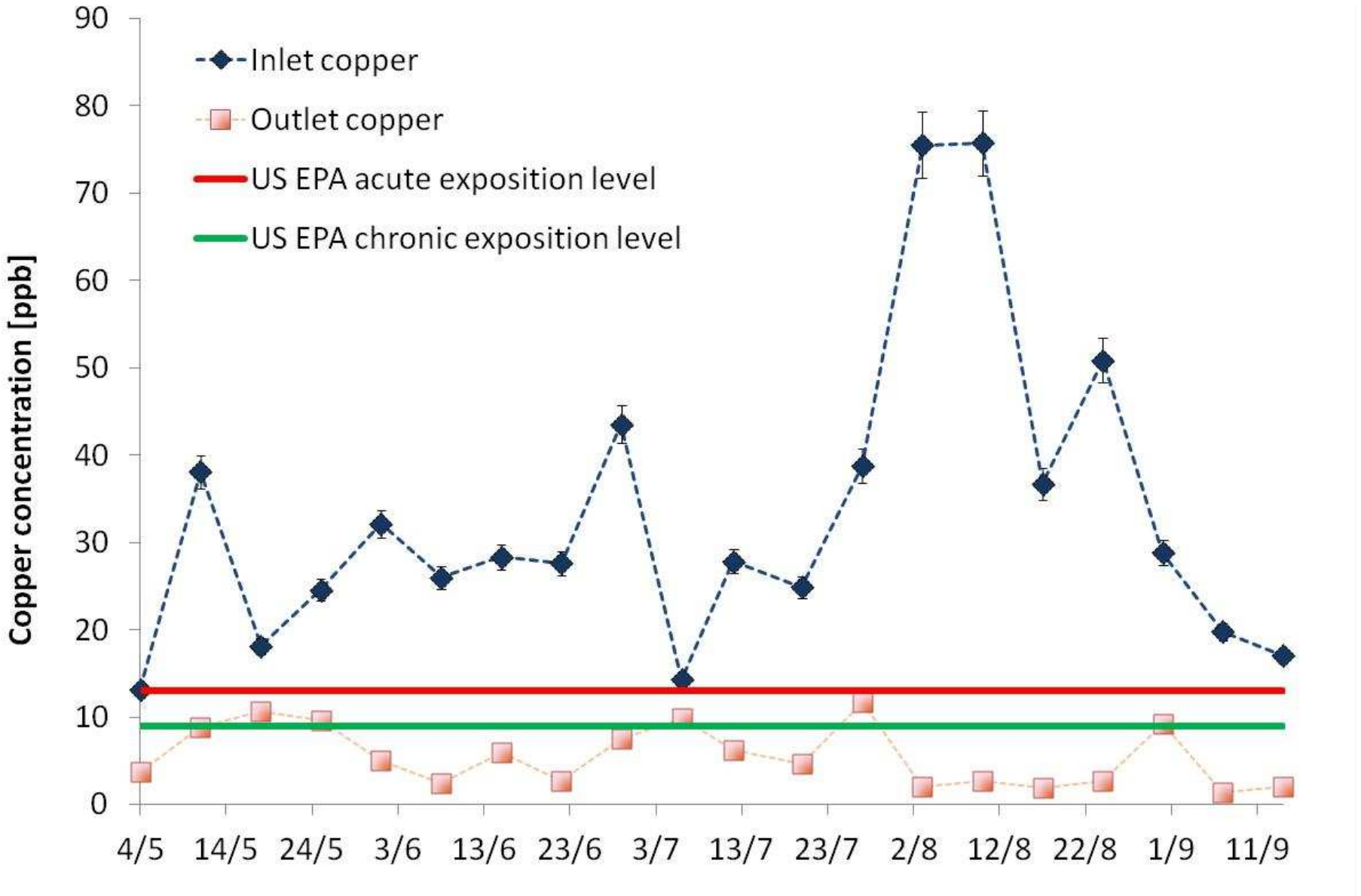
Copper use

Runoff discharge

Copper loads and retention

Babcsanyi et al. (In prep.), ES&T

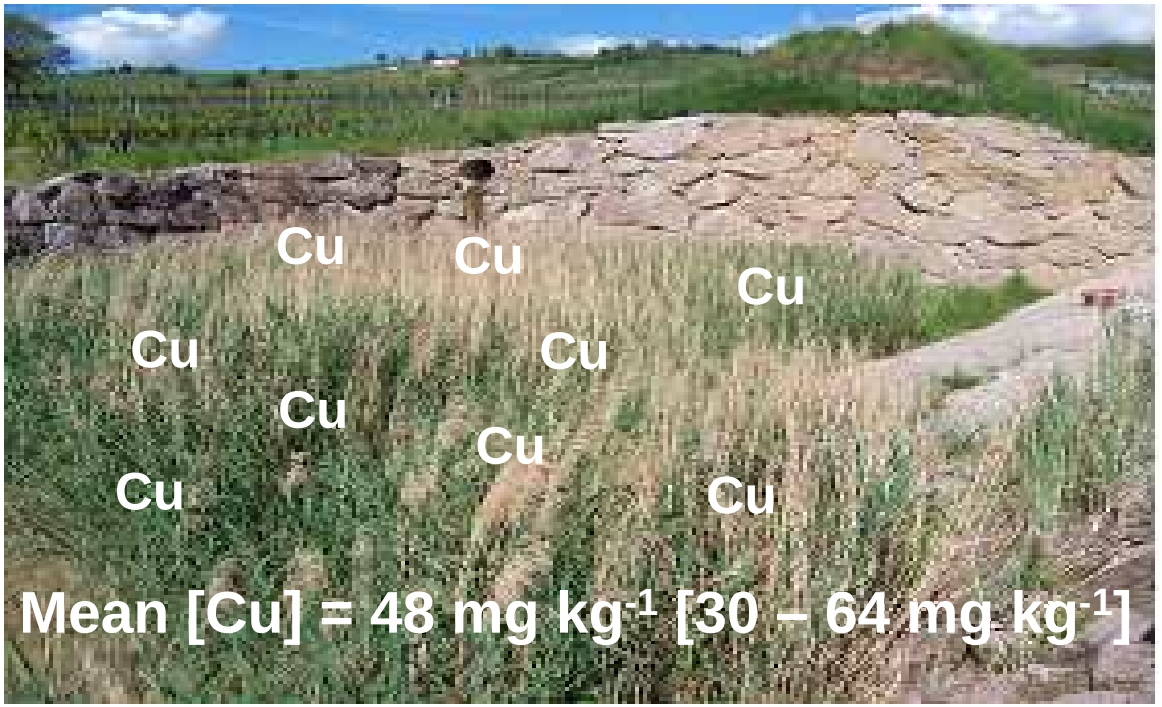
Copper concentrations



=> Decrease of copper concentration from wetland inlet to outlet

Babcsanyi et al. (In prep.), ES&T

Copper concentrations in wetland sediments (2011)



⇒ **Accumulation of copper in the wetland sediments**

⇒ **How to manage contaminated sediments?**

Conclusions

1. What is the capacity of stormwater wetlands to remove pesticide mixtures?

- Load removal: **between 39%** (simazine) **and 100%** (cymoxanil, gluphosinate, kresosxim methyl and terbuthylazine)
- Low transfer from the water column to the sediments (or fast degradation in sediment)
- Trapping of solids (> 90%) and hydrophobic pesticides (LogK_{ow} > 3)

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3. How stormwater wetlands retain copper?

- Copper concentration **decreased below the toxicity exposition levels**
- **82% of inlet copper load trapped** in the wetland
- Copper isotope composition analysis: sorption to Al- and Fe(hydro)oxides is critical

Stormwater wetlands:
=> Complementary tools for managing contaminated runoff from agricultural catchments?
=> Dynamic system for studying the transfer of pesticides



Thank you!

Research group: « Wetland biogeochemistry and contaminant transfert »
(UMR 7517 UdS-CNRS) http://lhyges.u-strasbg.fr/

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