Discharge conditions control the retention of pesticides in wetland buffer systems

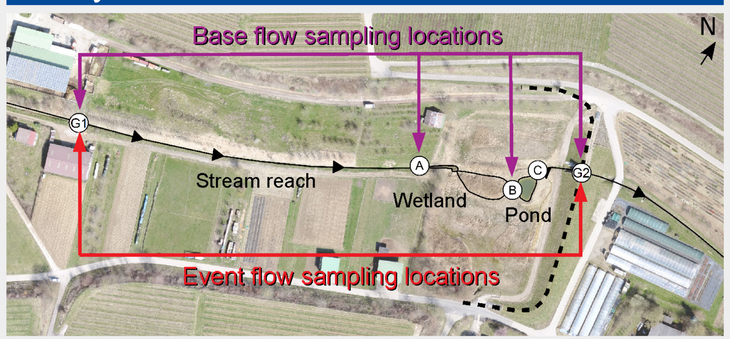
Jan Greiwe [1], Birgit Müller [1], Birte Hensen [2], Oliver Olsson [2], Jens Lange [1]

Motivation

- Wetland buffer zones are known to be efficient means for the retention of nutrients and pollutants
- No land-use conflicts when implemented in existing storm water retention basins

Are wetland buffer zones effective means for pesticide retention?

Study site



G1 Upstream gauge
G2 Downstream gauge
Vineyards
Cropland

Storm water retention basin in the wine growing region of the Kaiserstuhl, South-West Germany

Methods

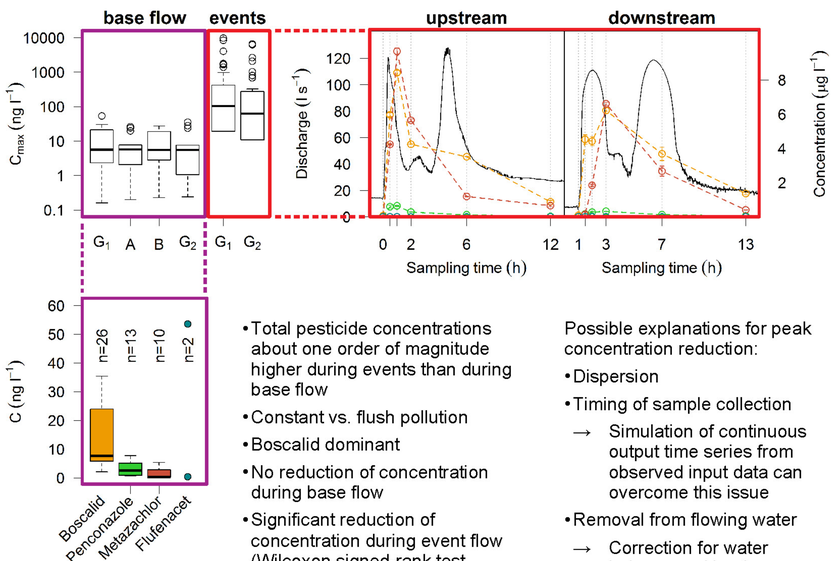
Pesticide sampling

- 7 sampling campaigns during base flow
- 15 automated sample collections during flow events (6 samples at predefined intervals)
  Upstream: 0, 0.5, 1, 2, 6, 12 h
  Downstream: 1, 1.5, 2, 3, 7, 13 h
- 1 automated tracer experiment (constant rate injection of NaBr for 30 min and automated sampling at G2)

Pesticide analysis

- Target compounds:
  2 Fungicides (Boscalid, Penconazol)
  2 Herbicides (Metazachlor, Flufenacet)
- Analysis at Institute of Sustainable and Environmental Chemistry, Leuphana Universität Lüneburg
- Duplicate water samples prepared by solid phase extraction and analyzed by LC-MS/MS (triple quadrupole)

Is our buffer system able to reduce peak concentrations?

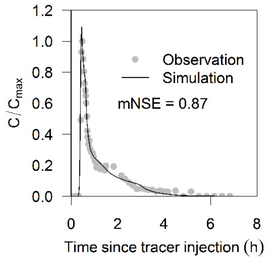


- Total pesticide concentrations about one order of magnitude higher during events than during base flow
- Constant vs. flush pollution
- Boscalid dominant
- No reduction of concentration during base flow
- Significant reduction of concentration during event flow (Wilcoxon signed-rank test, $p < 0.01$)

Possible explanations for peak concentration reduction:

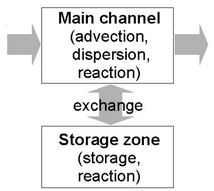
- Dispersion
- Timing of sample collection
  → Simulation of continuous output time series from observed input data can overcome this issue
- Removal from flowing water
  → Correction for water balance and load calculation

A question of timing: Can a transport model reproduce our downstream data?

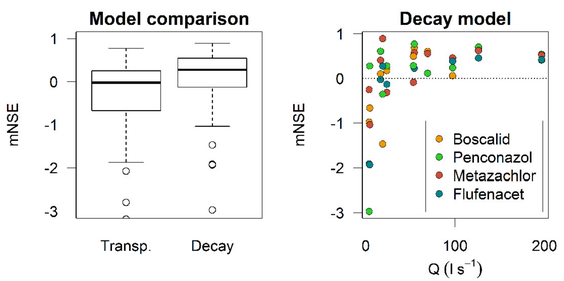


- Calibration of the transport model with bromide tracer data
- Application of the calibrated model to the flow events where pesticide samples were taken.
- Comparison of the transport-only model to a version in which load reduction was implemented by adding a first-order decay parameter (λ).

OTIS (Runkel, 1998)
Transient storage model



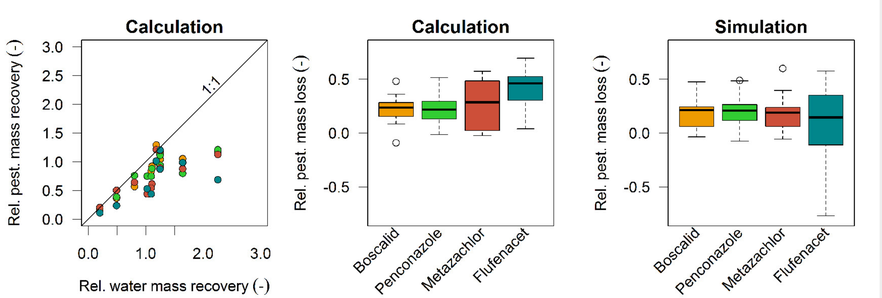
Decay model performs better than transport only



- Decay model performed significantly better (Wilcoxon signed-rank test, $p < 0.01$) than the transport only version
- Model provided meaningful simulations (mNSE > 0) in most cases where discharge was above 30 l/s.

Do lower concentrations mean less pesticides?

- Mass balance not closed for neither pesticides nor water
- Higher relative recoveries of water mass than of pesticide mass indicate pesticide mass loss
- Pesticide mass loss in almost all cases
- Both calculated and simulated mass losses scatter around 20 %



Conclusions

→ Reduction of concentrations during event flow, not during base flow
→ Loss of pesticide mass during event flow
→ Wetland buffer zones are effective for mitigation of flush pollution

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Reference: Runkel, R. L. (1998). One-dimensional transport with inflow and storage (OTIS): A solute transport model for streams and rivers.