Transport of Isoproturon, Metalaxyl and Artificial Tracers in Lab-Scale Wetlands

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HYDROLOGY

Role of wetlands in contaminant transport

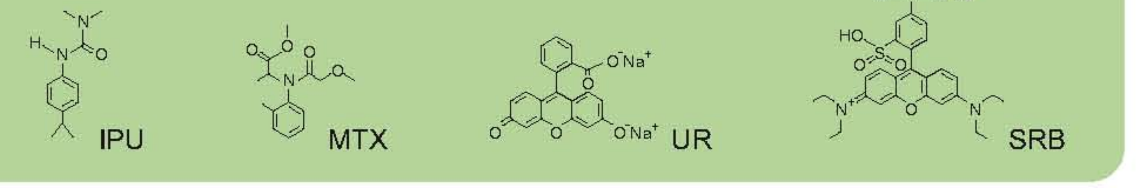
Rivers and surface wetlands can collect contaminated runoff from urban or agricultural catchments. They have intrinsic, physical, chemical and biological retention and removal processes useful for mitigating contaminants, including pesticides, and thus limiting the contamination of aquatic ecosystems. Yet little is known about the transfer of pesticides between wetlands collecting pesticide runoff and groundwater, and the subsequent threat of groundwater contamination. In particular, the influence of wetland vegetation and related processes during pesticide transport are largely unknown.

Objectives

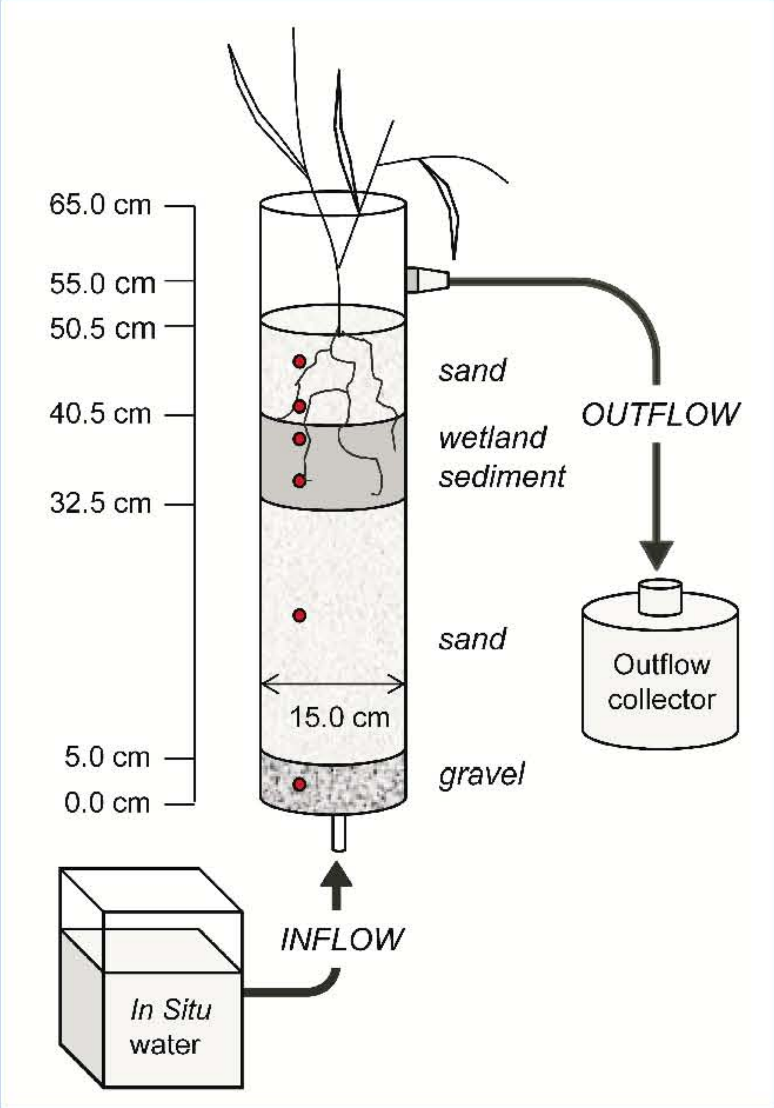
- To obtain process knowledge on contaminant transport from surface wetlands to groundwater.
- To study solute transport through saturated wetland sediments by laboratory experiments.
- To compare fluorescent tracers with two common pesticides in a long-term study.
- To investigate the influence of wetland vegetation.

Flourescent tracers as a reference for pesticides

In wetlands, the fluorescent tracers Uranine (UR) and Sulforhodamine B (SRB) may serve as a proxy for the environmental behaviour of certain pesticides. For the herbicide Isoproturon (IPU) this has been shown in 5-day field experiments including (i) passage through organic topsoil, (ii) underground passage through drainage lines, and (iii) open water flow (Lange *et al.*, 2011; Passeport *et al.*, 2010). However, biogeochemistry and hydrology of wetlands is complex as is the chemical variety of applied pesticides. Hence, there is further need to evaluate the feasibility of fluorescent tracers as a reference for pesticides. In this study we applied UR, SRB, IPU and the fungicide Metalaxyl (MTX).



Setup

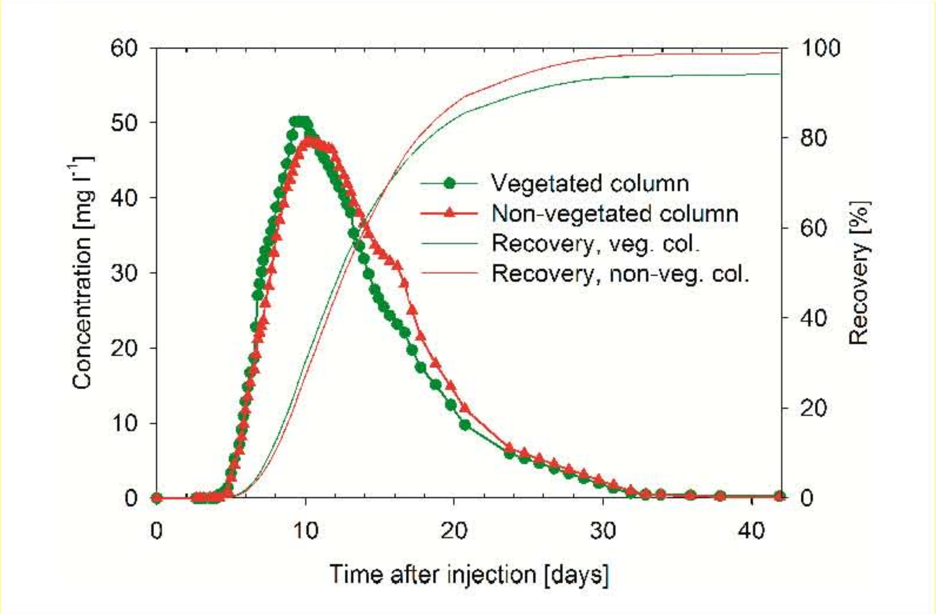


We filled two 65 cm long and 15 cm diameter borosilicate columns with sediment cores from a wetland (80% silt, 10% clay, 10% sand), one without and one with vegetation (*P. australis, Cav.*). Columns were covered with aluminium sheets to prevent light decay and evaporation losses. When a constant flow-through rate of 0.33 ml min^{-1} was reached, hydraulic properties of the systems were investigated by an instantaneous injection of 200 mg of bromide. Thereafter, fluorescent tracers (UR, SRB) and pesticides (MTX, IPU) were injected simultaneously and continuously for 35 days. In the following 50 days, water without contaminants and tracers was supplied to both columns. The water balance and tracer concentrations were measured daily at the outlet of the columns. Samples for pesticides and hydrochemical analyses were collected biweekly. UR and SRB were quantified by luminescence spectrometry (Perkin Elmer LS 50 B). MTX and IPU were analysed according to the NF XPT 90-210 at the Pasteur Institute of Lille (France) using liquid chromatography coupled to tandem mass spectrometry (LC-MS-MS).

Results

Instantaneous injection

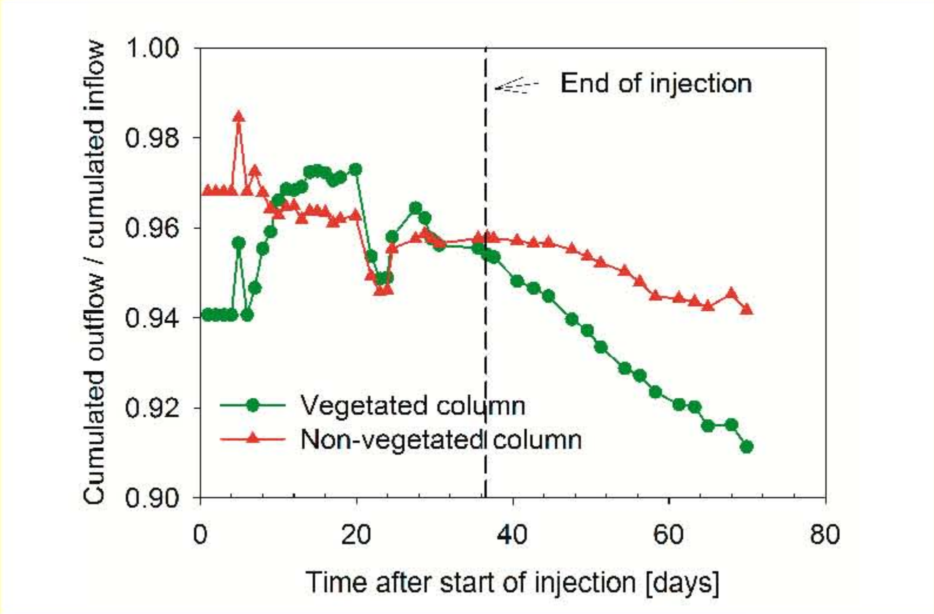
Bromide breakthrough in both columns



The breakthrough curve (BTC) of the vegetated column peaked higher (50.2 mg l^{-1}) and had a lower t_{50} (298 h) than the non-vegetated column (47.5 mg l^{-1}, 304 h, respectively). This suggested preferential flow paths along plant roots in the vegetated setup. However, recovery rates were smaller in the vegetated (94.2 %) than in the non-vegetated column (98.8 %). This may be due to plant uptake of bromide, which had already been reported for wetland vegetation (Xu *et al.*, 2004).

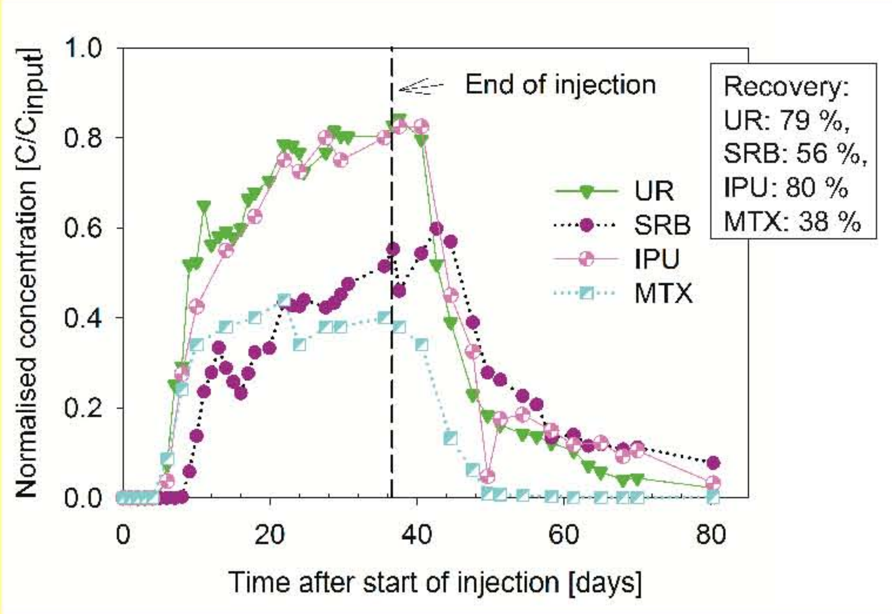
Continuous injection

Water balance in both columns

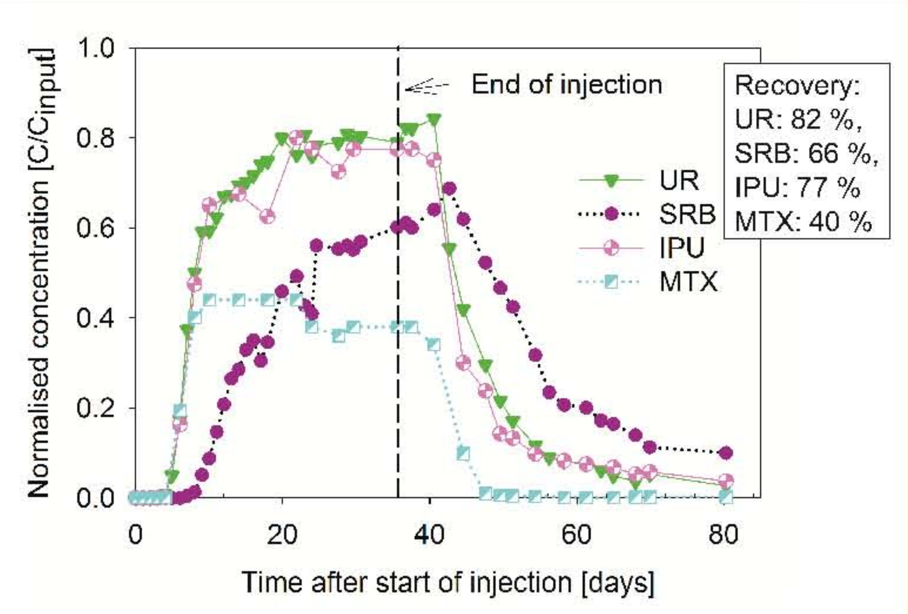


The water balance revealed the intensity of transpiration and hence plant activity and stress following pesticide injection. First, outflow rates of the vegetated column were smaller than in the non-vegetated control due to transpiration losses. After about eight days of continuous pesticide injection, transpiration virtually ceased in the vegetated column, causing larger outflow rates. Apparently, transpiration rates recovered after pesticide and tracer injection was stopped.

Non-vegetated column



Vegetated column



For all components, the arrival was faster in the vegetated than in the non-vegetated system, suggesting preferential flow already indicated by the instantaneous injection. In both the planted and the unplanted columns, the transport of UR and IPU was close and characterized by high mobility and low retention. The arrival of SRB was retarded and its BTC-tailing elongated suggesting reversible sorption. Also the effect of preferential flow causing lager recovery in the vegetated column was most prominent for SRB. Small recovery rates and a different shape of the BTC suggested permanent retention or even biodegradation of MTX. Overall, it can be seen that also in long time scales and in complex systems fluorescent tracers may serve as a reference for mobile pesticides.

Plant development at the end of the experiment indicating preferential flow along pant roots

Conclusions

- Fluoresent tracers can be used as a proxy to study the long-term transport of pesticides at the surface-groundwater interface.
- The transport of sorptive solutes in saturated wetland sediment was particularly large in the planted column and may be enhanced by plant roots.
- Significant attenuation of Metalaxyl was observed in both the planted and the unplanted columns.
- The behavior of Isoproturon was very similar to that of Uranine, which is usually considered as a conservative tracer in groundwater studies; this underlines that Isotoproturon may particularly threat the groundwater quality when transported through the surface-groundwater interface.

References: Lange, J., Schütz, T., Gregoire, C., Elsässer, D., Schulz, R., Passeport, E., Tournebize, J. (2011): Multi-tracer experiments to characterize contaminant mitigation capacities for different types of artificial wetlands. International Journal of Environmental Analytical Chemistry, Vol. 91, 768 - 785.
Passeport, E., Tournebize, J., Jankowski, S., Prömse, B., Chaumont, C., Coquet, Y., Lange, J. (2010): Artificial Wetland and Forest Buffer Zone: Hydraulic and Tracer Characterization. Vadose Zone Journal, Vol. 9, 73 - 84.
Xu, S., Leri, A. C., Myneni, S. C. B., Jaffe, P. R. (2004): Uptake of Bromide by two wetland plants. Environmental Science and Technology, Vol. 38, 5642 - 5648.

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