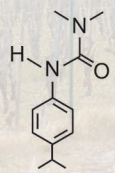
Fluorescent Tracers as a Reference for Pesticide Transport in Wetland Systems

Jens Lange [1], Tobias Schuetz [1], Elodie Passeport [2], Julien Tournebize [2]

HYDROLOGY

The contaminant

Isoproturon (IPU) $C_{12}H_{18}N_2O$



Priority substance according to EU-WFD
Common herbicide to control weeds
More than 1000 t/y applied in Germany
Half Life (DT_{50}): soil 6-23d, water 20-61d
Solubility (water): 70.2 mg/l, highly mobile
Often found in surface- and groundwaters
Toxic for algae and aquatic organisms
Analysis costs: ~ 60.- € per sample

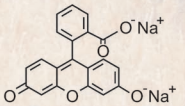
Basic idea

Wetlands may serve as ecological bioengineering methods to reduce pesticide pollution from agricultural land into surface water.
In this context non-conservative tracers may be used as a surrogate for contaminants (e.g. pesticides) to study their environmental behaviour.
This study compares the pesticide Isoproturon (IPU) with the fluorescent tracers Sulphorhodamine (SRB) and Uranine (UR).
Using UR and SRB mitigation capabilities of different wetlands are illustrated.

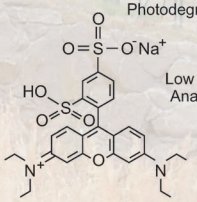
The tracers

Uranine (UR)

$C_{20}H_{10}Na_2O_5$, fluorescein
Most common fluorescent tracer in groundwater
Photodegradation: half life (DT_{50}): 11 h
Solubility (water): 600 g/l, low sorptivity
Detection limit: 0.002 µg/l
Low toxicity in aquatic ecosystems
Analysis costs: < 5.- € per sample



Sulforhodamine B (SRB)

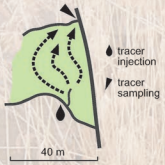


$C_{27}H_{29}N_2NaO_7S$
Photodegradation: half life (DT_{50}): 820 h
Solubility (water): 10 g/l,
Relatively high sorptivity
Detection limit: 0.01 µg/
Low toxicity in aquatic ecosystems
Analysis costs: < 5.- € per sample

Wetlands for comparison

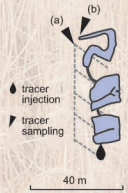
Forest buffer zone

1600 m² forest stand of oak (Quercus robur)
Soil with high clay content (37% at a depth of 45 cm)
Intermittend inflow extracting water from an agricultural drainage ditch
Water is distributed on the forest soil by a ditch system
Flow approx. 70 m through shallow organic topsoil-layer



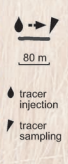
Surface flow wetlands

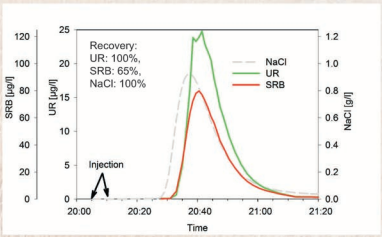
Three wetlands in series with maximum depths of 0.70, 0.77 and 0.14 m
Total area 1280 m², total water volume of 330 m³
Vegetation cover approx. 10%, constant inflow rate of 1.4 l/s
Approx. 30% of the inflow exites the wetlands through underground drainage pipes
Two outlet measurements: (a): drainage collector, (b) surface outlet



Tracer application to a densely vegetated ditch

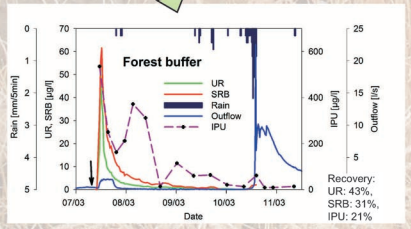
UR and SRB were injected into a straight 80 m ditch densely vegetated by Phragmites australis.
During the experiment water depth was shallow (10 cm) owing to a very small discharge (0.9 l/s).
Total water volume: 4 m³.

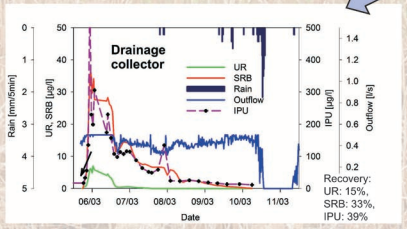


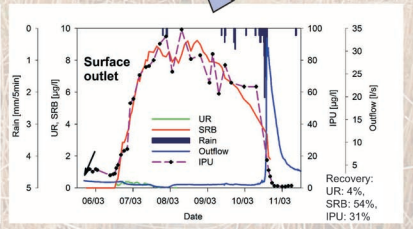


Similar SRB-recovery rates were obtained in only 1.2% of the water volume (compared to the surface flow wetlands), UR passed the wetland without loss.

Comparison IPU - Tracers







Analysis costs limited IPU sampling frequency and single samples deviated from the tracer breakthrough curve.
Still, a rather parallel behavior of IPU and SRB could be observed at all sampling points with similar recovery rates.

Conclusions

A similar environmental behaviour of IPU and SRB was observed in totally different wetland systems.

These are all relevant for contaminant export from agricultural areas and include:
- passage through organic topsoil,
- underground passage through drainage lines,
- open water flow.

Thus SRB may serve as a "reference tracer" for IPU in wetland studies.
UR may serve as proxy for photolysis, this however deserves further investigation.
SRB shows that dense vegetation covers and shallow water depths promote tracer loss and hence contaminant mitigation in wetlands.

(1) Institute of Hydrology, Albert-Ludwigs-University of Freiburg
jens.lange@hydrology.uni-freiburg.de www.hydro.uni-freiburg.de
(2) CEMAGREF, Antony, France
www.cemagref.fr

This work was financed by the European Union in the framework of the LIFE-Project ArtWET (06 ENV/F/000133)