Effects of emerging wetland vegetation on solute transport processes

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Objectives
- To assess the distribution of multi-tracers and conceptual solute transport models for two characterized wetland aquifer transport processes.
- To test if the use of the emerging vegetation on wetland hydraulics and physico-chemical retention processes is feasible.
- Can we use this approach to predict solute transport?

Methods

Three tracers for model calibration
- Bromate (BR) - conservative
- Sorbitol (SRB) - sorptive
- Urea (UR) - photo degradable (almost non-sorptive)

A forth tracer to check model quality
- Eosin (EOS) - photo degradable sorptive

Four multi-tracer experiments were conducted with 2 different injection techniques
- Slug injection (SI)
- Constant Rate Injection (CRI)

Solute transport
- Transient storage modelling

OUTSIDE Environment
- One-Dimensional Transport with Inflow and Storage (QSEU)

Study Site

Non-Vegetated March 2010
Vegetated August 2010

Calibration parameters
Calibration with

Conservative transport parameters
- A: Total wetland cross section (m²)
- β: Fraction of Storage Zone (%) (γ)
- D: Dispersion coefficient (m²/s)
- α: 1st order exchange coefficient (γ/s)

Sorption parameters
- k: Sorption rate coefficient (γ/s)
- β: Sediment concentration (g/L)

Light decay parameters
- k' : Main Channel decay rate coefficient (γ/s)
- k" : Storage Zone decay rate coefficient (γ/s)

Parameter estimation
- For each tracer 30,000 Monte-Carlo runs
- Objective function: Nash-Sutcliffe Efficiency

Results

Overview on tracer experiments

<table>
<thead>
<tr>
<th>Wetland State</th>
<th>Method</th>
<th>Time (s)</th>
<th>BR</th>
<th>SI</th>
<th>SRB</th>
<th>Urea</th>
<th>EOS</th>
<th>Time (s)</th>
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</thead>
<tbody>
<tr>
<td>Non-Vegetated</td>
<td>SI</td>
<td>0.01</td>
<td>10</td>
<td>398/41</td>
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<td>1/1.9</td>
<td>0.5/3.3</td>
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<tr>
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<td>0.01</td>
<td>3.2</td>
<td>388/97/0.2/38</td>
<td>1.3/8.3</td>
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<tr>
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<td>CRI</td>
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<td>6.9</td>
<td>730/101/1.1/69</td>
<td>1.6/8.6</td>
<td>1.1/5.6</td>
<td>2.1</td>
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</tr>
</tbody>
</table>

Model quality check - Transport prediction

- Eosin transport was predicted with deviations to observed tracer recoveries within 2% to 10%
- The interaction of retention processes could be reproduced

Conclusions

- The chosen methods were suitable to determine reduced solute retention times and increasing solute peaks as an effect of emerging wetland vegetation.
- The application of tracers with different physico-chemical properties allows us to quantify an increase of sorption in vegetated stores and to determine the size of areas where light decay is active.
- Retention processes determined by these different tracers were successfully applied to predict the transport of a forth independent tracer

Due to the common use of constructed wetlands as bio-treatment systems, there is a need to understand 10 quantifying and predicting how these systems treat pollutants and include micro-pollutants in surface flow wetlands (SFV).

Modelled results CRI experiments

Calibration results all experiments

Effects on conservative transport
- Effective wetland cross section was reduced ~50 %
- Dispersion increased
- Lateral exchange decreased

Effects on sorption processes
- Main Channel sorption remained ~ constant
- Storage Zone sorption increased

Effects on light decay
- Light Decay was dominant (minimum a factor 50) in the Main Channel Zone (all cases)
- Storage Zone light decay was negligible in the vegetated SFV

This work was financed by the European Union in the frame of the HYDROLOGY project, FP6-212499-ECN (http://www.hydrology.org)