Macrophyte growth module for the SWAT model

Impact of multi-stressors on stream ecology

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WHY

Multiple pressures on water & ecology:
  › Management, land use, climate change
  › Model for catchment response

Macrophyte
  › Ecological indicator
  › Change river physical & chemical condition

Macrophyte for SWAT
  › Modified INCA-P for macrophyte growth
  › Benthic sediment
Modified INCA-P

Growth

Well mixed water column

Temperature

Light

Death

Flow rate

Respiration

Sediment

Nutrient N/P
SWAT in-stream model QUAL2E

Well mixed water column

O\(_2\)

C-BOD

Reaeration

\(\text{NO}_3\)

\(\text{NO}_2\)

\(\text{NH}_4\)

\(\text{Org N}\)

\(\text{Algae}\)

\(\text{Dissolved P}\)

\(\text{Particulate P}\)

Missing sediment N & P processes

Benthic Sink/Source for Nutrients
SWAT + Benthic sediment

Well mixed water column

Oxygen (O2)

Reaeration

Nitrate (NO3)

Nitrite (NO2)

Ammonium (NH4)

Organic N (Org N)

Algae

Dissolved P (P)

Particulate P

Deposition/Re-suspension

Deposition/Re-suspension with sediment

Sediment

Sink

Nitrification

Denitrification

New processes

QUAL2E

Inflow

Diffusion

Dissolved P

PP

Deposition/Re-suspension with sediment

Sink

Outflow
SWAT+ Macrophyte

Well mixed water column

Temperature
Light
Flow rate
Respiration

Sediment Sink

NO3 NH4 Org N PP Dissolved

Deposition/Resuspension with Sediment
Deposition/Resuspension with sediment
Deposition/Resuspension with sediments

New processes
QUAL2E
Study site: Gryde river Denmark

<table>
<thead>
<tr>
<th>Location</th>
<th>Northwestern Jutland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>30 km²</td>
</tr>
<tr>
<td>Land use</td>
<td>Agriculture 67%</td>
</tr>
<tr>
<td></td>
<td>Forest 31%</td>
</tr>
<tr>
<td></td>
<td>Wetland 2%</td>
</tr>
<tr>
<td>Hydrology</td>
<td>Precipitation 1023mm</td>
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<tr>
<td></td>
<td>ET 547 mm</td>
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<tr>
<td></td>
<td>Discharge 249 mm</td>
</tr>
<tr>
<td></td>
<td>Groundwater &gt; 70%</td>
</tr>
<tr>
<td>Observation</td>
<td>Discharge 1977-93</td>
</tr>
<tr>
<td></td>
<td>Macrophyte 1977-87</td>
</tr>
</tbody>
</table>
Discharge

- Not satisfying
  - Small variation in observation
  - Different surface / ground water domain

![Graph showing discharge over time with NSE = 0.52 and PBIAS = 3.60](image)
Macrophyte: 10 year daily biomass

- Observation/simulation period not same
- Seasonal dynamic match
Macrophyte & Stream flow

- Macrophyte growth in streams
  - Increase roughness
  - Slow down flow velocity
  - Reduce sediment erosion & increase deposition
- SWAT manning’s N static
- Manning’s N related with macrophyte biomass
Dynamic Manning’s N

› Change with macrophyte biomass
› Seasonal dynamic & magnitude
› Improve relationship with macrophyte biomass
   › Fix magnitude
Impact on Flow

- Limited change on discharge
- Change flow velocity
  - Lower in summer
  - Higher in winter
Impact on Transport: Default sediment routing

- Sediment & particulate N, P - very limited impact
  - Default sediment routing – use discharge not flow velocity
Impact on Transport: Physical sediment routing

- **Sediment:** more erosion with macrophyte
  - Physical erosion use water depth, not flow velocity
- **Organic N & P:** less with macrophyte
  - Loss due to deposition units
Further work

› Improve manning’s N dynamic
› Sensitivity analysis / Climate change
  › Solar radiation
  › Temperature
› Epiphyte component
› Sediment erosion based on flow velocity
  › correct response to macrophyte growth
› Denitrification in benthic sediment

Please come to our poster in the afternoon:
A SWAT model for Denmark