AN IMPROVED SYSTEM FOR ASSESSMENT OF WATER POLLUTION FROM DIFFUSE SOURCES IN SERBIA – CASE STUDY FOR KOLUBARA RIVER BASIN

Побољшање система за процену дифузног загађења вода у Србији - Студија случаја за слив Колубаре

PRINCIPLES OF MODELING AND ASSESSMENT OF DIFFUSE LOAD

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Definitions

Point sources
= all sources with distinct emission points and end-of-pipe control
- industrial plants
- wastewater treatment plants
- sewage
- aquaculture plants

Diffuse sources
= all sources not regarded as point sources
- Atmospheric deposition on lakes
- Landuse: Agriculture, Urban, Forest, Wetlands, Unmanaged land
- Background losses from managed land
- Scattered dwellings from household not connected to sewer system
Principle sources, load pathways

Difficult to monitor diffuse sources pathways
Description of principle diffuse load

- **Atmospheric deposition:**
  lake area * deposition kg/m²

- **Landuse:**
  area * leaching concentration * runoff

- **Scattered dwellings:**
  residents * load per person * retention in sewage treatment

- **Manure storage:**
  number of animals * load of nutrients per animal * leaching percentage
Large principle diffuse source is landuse

- Geographical Information System GIS needed to describe the distribution of landuse area
- Corinne landcover available for principle landuse in Europe
- Additional information needed to describe agricultural area
Landuse description

- **Area:**
  - Crop area or crop percentage of total arable land
  - GIS

![Bar chart showing Total P kg/ha](chart.png)

- Total P kg/ha
- Root zone leaching
- Surface runoff

<table>
<thead>
<tr>
<th>Crop</th>
<th>Läckage (kg P/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>vår-korn</td>
<td></td>
</tr>
<tr>
<td>höst-vete</td>
<td></td>
</tr>
<tr>
<td>vall</td>
<td></td>
</tr>
<tr>
<td>socker-betor</td>
<td></td>
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<tr>
<td>höst-raps</td>
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<tr>
<td>träda</td>
<td></td>
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<tr>
<td>havre</td>
<td></td>
</tr>
<tr>
<td>vår-vete</td>
<td></td>
</tr>
<tr>
<td>råg</td>
<td></td>
</tr>
<tr>
<td>potatis</td>
<td></td>
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</tbody>
</table>
Landuse description

• Area:
  - Soil type area in the catchment,
  - GISP maps or statistics
  - Soil management

![Graph showing soil type vs. phosphorus leakage (in kg/ha)]
Landuse description

• Leaching concentration
  - monitoring data, empirical input
    *or*
  - model results assessed against monitoring data
Landuse description

- Runoff can be determined by
  - flow monitoring or rating curves against water level
  - calculated runoff calibrated against monitoring data
  - modeling of the runoff from climate and catchment conditions
Scattered dwellings and manure storage

- Statistics on residents: municipal or better information
- Load per resident
- Statistics on animals: municipal or better information
- Load per animal
- Retention from sewage system/storage to recipient
Delineation of catchments

Define catchment borders and flow network

• Digital Elevation Map, rivers and lakes
• Point source near inlet
• Monitoring station and lakes at outlet
Retention in lakes

- Load is reduced in lakes due to:
  - Sedimentation
  - Plants uptake
  - Animal uptake
  - Denitrification

- Retention is more effective during warm seasons
Retention in lakes

Total Nitrogen concentration
Model results
Without retention – black line
With retention – purple line

Monitoring data – standing pilar

Skivarpsån Sweden, model for HELCOM PLC4 and WFD
Principles of load and retention calculation

<table>
<thead>
<tr>
<th>Gross load (Ton/yr)</th>
<th>Retention (%)</th>
<th>Net load (Ton/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>10</td>
<td>(5 \times 0.9 = 4.5)</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>((10 + 4.5) \times 0.85 = 12.76)</td>
</tr>
<tr>
<td>15</td>
<td>20</td>
<td>((15 + 12.76) \times 0.8 = 22.21)</td>
</tr>
</tbody>
</table>
Modelling - for what purpose?

The purpose needs to be defined before application

- Source apportionment
- Programmes of measures
- Modelling investigation of failure to meet good quality
Model concepts

Model type

- Physical
- Empirical

Level of complexity

- High
- Low

Daily simulations of flow and solute concentrations:

- SWAT, HSPF
- WARMF
- HYPE

Annual predictions based on export coefficients:

- FYRIS-NP
- MIKE BASIN
- AWGWLF-PREDICT

Rewritten from EUROHARP documentation

• Combination of models above – conceptual models
Model concepts

Advantages and limitations

Model type

- Physical
  - SWAT, HSPF, WARMF, HYPE

- Empirical
  - FYRIS-NP, MIKE BASIN, AWGWLF-PREDICT

Advantages
- Process descriptions
- Scenarios possibilities
- Low data requirements
- Simple models

Limitations
- Expert user
- High data requirements
- Time-consuming
- Few scenario possibilities
- Valid only for model range
Temporal and spatial resolution

- **Year**
  - AWGWLF-PREDICT

- **Month**
  - FyrisNP
  - Mike Basin

- **Week**
  - HYPE
  - SWAT

- **Day**
  - LASCAM

Spatial resolutions:
- 10 km²
- 100 km²
- 10,000 km²
- 100,000 km²
Model tools

- General boxes included in modelling tools
Model choice in Kolubara - FyrisNP

- Source apportionment interface
- Good data and results interface
- Several retention calibration options
- Free to use
Calibration in FyrisNP

\[ R_t(t) = \left(c_0 + T \frac{1-c_0}{20}\right) \frac{k_{VS}}{q_i^{HL} + k_{VS}} \]

- \( R \) = Retention
- \( Ta \) = Temperature adjustment factor
- \( Qa \) = Flow rate adjustment factor
- \( q \) = hydraulic load (Q/A)
- \( c_0 \) = Empirical calibration parameter for temperature dependency
- \( k_{VS} \) = Empirical calibration parameter for hydraulic dependency
Assessments
Use of monitoring data

- Evaluate the model results against monitoring

Diagram:

- Massflux
  - $r = 0.91$
  - $Eff = 0.75$
Results – weakest link rule

- A good model need good drive data

- Example of faulty point source coordinates in an inlet watercourse to lake Vättern in Sweden,

- Model is an important tool of correction of data input!
Thank you!

My family
Lake Övre Hammardammen