Impact of current conservation practices on sediment load reduction in the Danube River Basin

Olga Vigiak, Anna Malagó, Fayçal Bouraoui, Marco Pastori, Pasquale Borrelli, Alberto Pistocchi

www.jrc.ec.europa.eu

Serving society
Stimulating innovation
Supporting legislation
Context of the research

- **Water Framework Directive** (WFD) requires freshwater bodies achieving good ecological status by 2015
- Conservation practices (Best Management Practices – BMPs) are at the core of strategies to achieve the WFD targets
- But what has been the impact of BMPs on pollution (e.g. sediments) so far?
- **Objective of the study** was to assess the impact of conservation practices already implemented on sediment reduction in a large European river basin (the Danube)
Workflow

- **BMPs estimation**
  - Spatial distribution
  - SWAT implementation

- **SWAT**
  - Model calibration
  - Current BMPs, 1995-2004

- **BMP effectiveness**
  - SWAT run without each BMPS
  - Ratio of sediment loads per regions
Best Management Practices

- Cover crops,
- Residue management,
- Conservation tillage,
- Terracing/contouring

- Riparian land (filter strips)

- Streambank protection
- Reservoirs/locks
The Danube Basin

~2700 km, 834000 km$^2$ area, 19 Countries

(4663 subbasins of 172 km$^2$ average)
Farming system BMPs

Eurostat 2010 data (Nuts2)

Cover crops: 15013 km² (4%) of arable land

Conservation (minimum or no till) tillage: 77469 km² (20%) of arable land

Residue management: 18400 km² (5%) of arable land

Terracing: fraction of holdings with stonewalls ~ proxy for terrace density; ranged 0-25% (weighted mean 1.3%)
**SWAT implementation**

<table>
<thead>
<tr>
<th>BMP</th>
<th>Approach</th>
<th>Applied to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover Crop</td>
<td>One year rotation (Arabi et al. 2008)</td>
<td>Annual crops</td>
</tr>
<tr>
<td>Conservation tillage</td>
<td>Minimum tillage (adapted from Ullrich and Volk 2009, Lam et al., 2011)</td>
<td>Annual crops</td>
</tr>
<tr>
<td>Residue Management</td>
<td>Change Harvest&amp;Kill into Kill</td>
<td>Summer cereals</td>
</tr>
<tr>
<td>Terracing</td>
<td>Manual USLE P/slope look-up * changes in LS factor * fraction of terraced land</td>
<td>pastures and permanent crops, Slopes 5-60%</td>
</tr>
</tbody>
</table>
Overview of farming system BMPs

Current farming system BMPs cover

471 Hrus - 23% of arable HRUs; 28% of arable land area

Terracing USLE P correction ranged 0.77 - 0.99

However, USLE P < 0.97 only in 10% of these HRUs
Riparian land map

Pan-European map of riparian vegetation types at 25m resolution (Clerici et al. 2013; Weissteiner et al. 2013) + CORINE wetlands

Modelled as filter strips

VSFRATIO ~ area of subbasin/area of riparian zone in the subbasin (limited in the range 10-200)

No data area: attributed characteristics of neighboring regions

Applied to pastures or cropland hrus
**SWAT implementation (ops table)**

original = from Clerici et al. map (2152 hrus)

final = including the nodata region (2815 hrus, 54%)

<table>
<thead>
<tr>
<th>Operation</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWAT2012 (filter.f)</td>
<td>FILTER_I (VSFI)= FILTER_RAT (VSFRAT)= FILTER_CON (VSFC) = FILTER_CH (VSCH) =</td>
</tr>
<tr>
<td>MNG_OP=4</td>
<td>1 10-200 0.25 0.10</td>
</tr>
</tbody>
</table>
Riparian land in the Danube (cropland and pastures)
In-stream (streambank & reservoirs/locks)

Clerici et al. 2013 riparian map (25m) used for estimating vegetation along the main stream (CH_COV; note: CH_EQN=3)

No data: values assigned depending on land use, slope and drainage area

Major reservoirs and hydropower plant locks (114) included
SWAT sediments (uncalibrated)

Inn - Passau Ingling

Morava - Devin

60000212 TSS (mg/L)

60000662 TSS (mg/L)
SWAT sediments (uncalibrated)

Donau - Esztergom

TSS (mg/L)

Year

6000777 TSS (mg/L)

observed

Predicted

Donau - Esztergom
SWAT sediments (uncalibrated)

Danube - DELTA

Tisa - Titel

60000122 TSS (mg/L)

6000073 TSS (mg/L)

TSS (mg/L)

Year


0 10 20 30 40

observed

Predicted

0 10 20 30 40

0 10 20 30 40

60000122 TSS (mg/L)

6000073 TSS (mg/L)

observed

Predicted

0 10 20 30 40

0 10 20 30 40


Year

1 July 2015

SWAT2015 Conference, Pula, 24-26 Jun 2015
Results example: (i) impact of riparian land at HRU scale
(ii) impact at reach scale

Efficiency of Riparian land in all reaches

Riparai land fraction

Efficiency riparian land

Riparial land fraction
(iii) Impact at regional scale

Efficiency of Riparian land in Danube regions

Specific Sediment Yield (t/km²)

No Riparian land
Current

Efficiency SSY

Upper Danube, Austrian Danube, Morava, Vah-Hron-Ipoly, Sava, Tisa, Velka Morava, Middle Danube, Jiu, Olt, Arges-Vlcea, Lower Danube, Buzau-Telomita, Siret-Prut, DeltA

1 July 2015

SWAT2015 Conference, Pula, 24-26 Jun 2015
Discussion

- Potential errors in spatial attributions of BMPs

- Literature reports different implementation of BMPs in SWAT (e.g. conservation tillage) -> impact on BMPs ‘effectiveness’

- Wetlands: currently SWAT only consider impact on the subbasin, cannot consider upstream reaches load (longitudinal connectivity)

- Careful calibration (water and sediments) is needed to achieve correct representation of sediment generated in land vs stream phase processes
Conclusions & outlook

Good general performance of SWAT for suspended sediment modelling even in uncalibrated conditions (but careful set-up)

This study will help revealing the real impact of BMPs on sediment (and in the future, on nutrients) at several scales (from local to regional)

The BMPs rules & calibrated SWAT model can be used for scenario analysis

Further contact: olga.vigiak@jrc.ec.europa.eu
Selected references


Weissteiner CJ, Bouraoui F, Aloe A. 2013. Reduction of nitrogen and phosphorus loads to European rivers by riparian buffer zones. Knowledge and management of aquatic ecosystems 408: 8