Assessment of water resources and quality in support to the EU Danube strategy


European Commission Joint Research Centre (JRC), Ispra, Italy

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Overview

I. Context and challenges

II. The JRC modeling approach

III. Water quantity and quality assessment

IV. Access and exchange of model results
The Danube Water Nexus (DWN) covers many water-related issues like water availability, water quality, water-related risks, the preservation and restoration of aquatic ecosystems, and biodiversity.

It also aims to analyze the interdependencies of different economic sectors competing for water, such as agriculture and energy.
Challenges

The JRC provides science-based support for the implementation of the Water Framework Directive’s programmes of measures in order to reach the good ecological status of freshwaters and enhance sustainable future use of water resources.

ECO-HYDROLOGICAL MODELLING

Tools and methodologies to predict water quantity as well as sediment, and nutrient loads to water bodies

Best management practices impact

Economic assessment
Model SWAT

- Semi-distributed watershed scale simulation model
- Application in large river basins
- Continuous time model (daily time step)

Arnold et al. (1998)
Spatial Scale

Total area: 834,000 km²
#model subbasins: 4663
#model Hydrologic Response Units: 5181
Modelling cascade

MODEL SETUP

- DEM, subbasin and rivers, climate data, management, main reservoirs (area >20km²), abstractions for public, energy and industrial uses

WATER

- Multi-site and process based calibration of streamflow (daily and monthly time steps)

SEDIMENT

- Multi-site calibration of annual sediment concentrations

NUTRIENTS

- Multi-site calibration of monthly N_NO₃, TN and TP concentrations

Malago’ et al., 2015. HSJ.; Malago’ et al., submitted; Pagliero et al. 2015. STOTEN; Vigiak et al. 2015. STOTEN
Mean annual water discharges (1995-2009), **708** stations

Collection (from GRDC, TNMN, LFU, EUROSION and many others), **validation** of data and loads estimation

Mean annual **sediment** concentrations and yields (1995-2009), **429 & 95** stations

Estimated **TN** mean annual loads (1995-2009), **132** stations
Results - WATER

Long mean annual water balances (1995-2009) at different scales

Malago’ et al., 2015.
Results - WATER
Discharges in each river (1995-2009) at different spatial and temporal scales

Mean Annual discharges (1995-2009)

Monthly discharges (m3/s)

Danube (Vilkova-Chilia)

Danube (Hercegszanto)

Sava (Sremska Mitrovica)
Results - SEDIMENT

Hillslope erosion, t/ha (mean annual values for the period 1995-2009)
Results - SEDIMENT

Mean annual sediment concentration, mg/L (1995-2009)
Preliminary sediment budget (Mt/y)

- Cropland: 84.8 Mt/y
- Pastures: 19.9 Mt/y
- Forest: 21.4 Mt/y
- Urban areas: 4.7 Mt/y

Hillslope erosion: 130.8 Mt/y (88%)
Stream erosion: 18.3 Mt/y (12%)

Channel deposition: 128.3 Mt/y (86%)
Reservoir/lock trapping: 13.8 Mt/y (9%)
Floodplain deposition: ~0 Mt/y

Sediment output: 6.9 Mt/y (5%)
Results - NUTRIENTS

Long mean annual nitrogen balances (1995-2009) at different scales

Legend
- Main Basins
- N_NO3_LEACH_kg/ha

- 0
- 1-3
- 4-5
- 6-10
- 11-15
- 16-25
- 26-50
- 51-100
- 101-150
- Subbasin

Map: N_NO3 leached from the soil profile (kg/ha)
Results - NUTRIENTS

Concentration of nutrients in each river (1995-2009) at different spatial and temporal scales

Mean Annual concentrations (1995-2009)

Monthly concentrations mg/l

Passau Ingling on Inn sub. 843

Conf. Danube Sendreni sub. 2463

Wien - Nussdorf sub. 958
Preliminary **Nitrogen budget (kg/ha)**

- **River**: 3%
- **Riparian**: 4%
- **Aquifer**: 6%
- **Soil**: 19%
- **Plant**: 68%

**Diagram**:
- Plant Yield retention: 50%
- Soil retention: 14%
- Aquifer Nitrates leached: 5%
- Soil diffuse sources: NDS
- Nfix: 28
- Nrain: 13
- Napp: 38
  - NO3fert: 22
  - NH3fert: 3
  - ORGNfert: 13

**River sources**:
- Point sources: 2.6
- River: 9
Preliminary Phosphorus budget (kg/ha)

- **Plant**: 92% retention
- **Soil**: 0% retention
- **Riparian**: 4% retention
- **River**: 4% retention

Diagram showing the flow and retention of phosphorus in different systems. The diagram includes arrows and values indicating the flow and retention percentages.
Model Benchmarking

WHAT IS IT?

Comparison of existing models/assessments of water balances and quality (sediment and nutrients)

WHY?

• Framing the uncertainty of any model (“all models are wrong”), therefore it is important to compare more than one model (an “ensemble”) to:
  - increase our confidence in the results
  - understand where one model may fail (and another model may give alternative answers)

Process representation

Results – Benchmarking

WARNING: Benchmarking and further work needed.

**SWAT Preliminary results (without reservoir retention)**

**MONERIS Emissions (before water retention)**

FLOW (m$^3$/s) average 2000-2009

TN (t/y) average 2000-2009

Malago’ et al., 2015. DIPCON Conference Berlin 14-18 September 2015
Optimization tool

Before Optimization

BSL
Mean annual N_NO3 (mg/l)

50 mg/l

How much I pollute?

After Optimization

UPPER DANUBE (132,000 km²)

Pareto optimal solutions

How much I earn?
Conclusions

Application of the SWAT model to the Danube region **expands the knowledge basis on water resources**, and helps assessing the impact of management solution in reducing pollution across the basin.

Investigation of **water resources at several spatial and temporal scales** provides specific support to sectorial EU policy areas.

Model benchmarking is helping **identifying region where knowledge gaps (data and processes) exist** and is strengthening the knowledge basis used in river basin management.

The combination of SWAT model with **economic cost-benefit tools** allows identifying **optimal mixes of conservation measures** to achieve river basin management objectives effectively.
Access and Exchange

The methodologies and findings will follow a peer review process in scientific journals.

Outputs, maps and attributes of findings will be accessible approximately in February 2016 in the water portal http://water.jrc.ec.europa.eu/

However, some preliminary outputs, maps and attributes are available at:

http://drdsi.jrc.ec.europa.eu/scenario
Thank you for your attention
References


