

Integrated water quality modelling in meso- to large-scale catchments of the Elbe river basin under climate and land use change

Cornelia Hesse

Abstract

In a changing world facing several direct or indirect anthropogenic challenges the freshwater resources are endangered in quantity and quality. An excessive supply of nutrients, for example, can cause disproportional phytoplankton development and oxygen deficits in large rivers, leading to failure of the aims requested by the Water Framework Directive (WFD). Such problems can be observed in many European river catchments including the Elbe basin, and effective measures for improving water quality status are highly appreciated.

In water resources management and protection, modelling tools can help to understand the dominant nutrient processes and to identify the main sources of nutrient pollution in a watershed. They can be effective instruments for impact assessments investigating the effects of changing climate or socio-economic conditions on the status of surface water bodies, and for testing the usefulness of possible protection measures. Due to the high number of interrelated processes, ecohydrological model approaches containing water quality components are more complex than the pure hydrological ones, and their setup and calibration require more efforts. Such models, including the Soil and Water Integrated Model (SWIM), still need some further development and improvement.

Therefore, this cumulative dissertation focuses on two main objectives: 1) the approach-related objectives aiming in the SWIM model improvement and further development regarding nutrient (nitrogen and phosphorus) process description, and 2) the application-related objectives in meso- to large-scale Elbe river basins to support adaptive river basin management in view of possible future changes. The dissertation is based on five scientific papers published in international journals and dealing with these research questions.

Several adaptations were implemented in the model code to improve the representation of nutrient processes including a simple wetland approach, an extended by ammonium nitrogen cycle in the soils, as well as a detailed in-stream module, simulating algal growth, nutrient transformation processes and oxygen conditions in the river reaches, mainly driven by water temperature and light. Although this new approaches created a highly complex ecohydrological model with a large number of additional calibration parameters, the calibration and validation of the SWIM model enhanced by the new approaches in selected subcatchment and the entire Elbe river basin delivered satisfactory to good model results in terms of criteria of fit. Thus, the calibrated and validated model provided a sound base for the assessment of possible future changes and impacts in climate, land use and management in the Elbe river (sub)basin(s).

The new enhanced modelling approach improved the applicability of the SWIM model for the WFD related research questions, where the ability to consider biological water quality components (such as phytoplankton) is important. It additionally enhanced its ability to simulate the behaviour of nutrients coming mainly from point sources (e.g. phosphate phosphorus). Scenario results can be used by decision makers and stakeholders to find and understand future challenges and possible adaptation measures in the Elbe river basin.