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Modeling diffuse phosphorus emissions to assist in best management practice designing

Adam Kovacs (1), Matthias Zessner (1), Mark Honti (2), and Adrienne Clement (2)

(1) Institute for Water Quality Management, Vienna University of Technology (akovacs@iwag.tuwien.ac.at), (2) Department of Sanitary and Environmental Engineering, Budapest University of Technology and Economics

A diffuse emission modeling tool has been developed, which is appropriate to support decision-making in watershed management. The PhosFate (Phosphorus Fate) tool allows planning best management practices (BMPs) in catchments and simulating their possible impacts on the phosphorus (P) loads. PhosFate is a simple fate model to calculate diffuse P emissions and their transport within a catchment. The model is a semi-empirical, catchment scale, distributed parameter and long-term (annual) average model. It has two main parts: (a) the emission and (b) the transport model. The main input data of the model are digital maps (elevation, soil types and landuse categories), statistical data (crop yields, animal numbers, fertilizer amounts and precipitation distribution) and point information (precipitation, meteorology, soil humus content, point source emissions and reservoir data).

The emission model calculates the diffuse P emissions at their source. It computes the basic elements of the hydrology as well as the soil loss. The model determines the accumulated P surplus of the topsoil and distinguishes the dissolved and the particulate P forms. Emissions are calculated according to the different pathways (surface runoff, erosion and leaching). The main outputs are the spatial distribution (cell values) of the runoff components, the soil loss and the P emissions within the catchment.

The transport model joins the independent cells based on the flow tree and it follows the further fate of emitted P from each cell to the catchment outlets. Surface runoff and P fluxes are accumulated along the tree and the field and in-stream retention of the particulate forms are computed. In case of base flow and subsurface P loads only the channel transport is taken into account due to the less known hydrogeological conditions. During the channel transport, point sources and reservoirs are also considered. Main results of the transport algorithm are the discharge, dissolved and sediment-bounded P load values at any arbitrary point within the catchment.

Finally, a simple design procedure has been built up to plan BMPs in the catchments and simulate their possible impacts on diffuse P fluxes as well as calculate their approximately costs. Both source and transport controlling measures have been involved into the planning procedure. The model also allows examining the impacts of alterations of fertilizer application, point source emissions as well as the climate change on the river loads. Besides this, a simple optimization algorithm has been developed to select the most effective source areas (real hot spots), which should be targeted by the interventions.

The fate model performed well in Hungarian pilot catchments. Using the calibrated and validated model, different management scenarios were worked out and their effects and costs evaluated and compared to each other. The results show that the approach is suitable to effectively design BMP measures at local scale. Combinative application of the source and transport controlling BMPs can result in high P reduction efficiency. Optimization of the interventions can remarkably reduce the area demand of the necessary BMPs, consequently the establishment costs can be decreased. The model can be coupled with a larger scale catchment model to form a “screening and planning” modeling system.