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A Review of Phosphorus Routines in Environmental Modeling

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Phosphorus (P) is an important plant nutrient, but at the same time, it is responsible for eutrophication of surface waters. Therefore, an improved understanding of P cycling in ecosystems is needed. Since most existing studies on this topic focus on P leaching from agricultural soils, there is a lack of P studies for other ecosystems. The German Priority Program (SPP) 1685 investigates P cycling from forested catchments. Apart from urgently needed field studies in this research area, there is a lack of process-based modeling approaches supporting hypothesis testing or projecting forest management and climate change scenarios.

Many hydrological models exist, but there is only a limited number of models considering solute transport, and even less models considering P transport in particular. Up to now, no comprehensive overview of P models is available, so we looked for models able of simulating P routing through soils.

We compiled information on a total of 24 P models currently applied in various ecosystems (mostly from agriculture) and classified them to identify relevant models and model structures. We especially focused on those models for which P routines have been already validated and on those that capture preferential flow, since this transport pathway is particularly relevant for P leaching in forest soils.

Ten of these 24 examined models are able to simulate preferential flow and feature validated P routines, thus their model structures seem to be favorable for applications in simulating P cycles in forested soils. Still, seven of these models simulate macropores oversimplified as direct runoff to groundwater or stream. Since research showed that macropores are an important transport route, especially for particulate P, these models are inappropriate for understanding transport mechanisms. The three remaining models do comprise more complex preferential flow routines, yet they do not provide readily available P routines, but only general solute transport. Thus, none of these 24 models is able to reveal information on the actual transport processes of P in forested soils as requested in our current work. Based on our model review we will present a conceptual model framework that allows overcoming the current limitation of process-based simulations of P fluxes in forest ecosystems.