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PhosFate: A model for cost-effective management of diffuse phosphorous emissions in watersheds by the localisation of emission hotspots

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The model PhosFate is a yearly averaged, semi-empirical and distributed parameter model for diffuse phosphorous (P) emissions into surface waters. Due to its high spatial resolution that is based on single raster cells of the investigated catchment area (with a current size of 10 x 10 m), and thus calculations of the emission and transport of P for every single cell, it enables to trace back phosphorous emission origins. Thereby, it considers erosion and surface runoff due to their dominant importance for the P transport to surface waters. PhosFate is able to identify and localize hot spots of P emissions and thus areas, which are particularly effective for implementing P emission reduction measures. Required input data are digital maps of elevation, land use, soil type, factors of the Universal Soil Loss Equation before and after the potential application of management practices, mapped water courses, and humus, clay and P contents of the topsoil. As initial research revealed a significant influence of drainages along roads on the discharge, drainages are further implemented in PhosFate by a direct transfer of the P emission transport from linear structures to the next closest surface water. The current version of PhosFate was applied to three catchment areas in Austria to identify so-called critical areas, which are areas with a high probability to contribute with a large share to total particulate P river loads. Further, it was used to assess the effect of two buffer-strip-like practices of the Austrian, agrarian environmental program ÖPUL 2015 and of other possible management strategies including buffer strips along rivers, streets, preferential flow paths and within agrarian fields as well as changes in the cultivation method on the reduction of particulate P emissions from agricultural land. Overall, the spatial implementation of the ÖPUL program is small ranging from 0.1 to 1.6 % of the agricultural land and consequently, the calculated emission reduction of in average 3 % is low. The small converted area and the negligence of a prior implementation on critical areas further resulted in a low efficiency (as a ratio of emission reduction to converted area) of the investigated ÖPUL measures. In contrast, through a combined implementation of buffer strips along rivers, streets and preferential flow paths in solely critical areas directly connected to the river system, high reductions of particulate P river inputs of 45, 33 and 48 %, and an efficiency of 4, 4 and 2 kg ha 1 a 1 could be achieved for the three catchments respectively. Furthermore, the extent of critical areas and thus areas with a high probability in large P emissions could be reduced from 18 to 3 % exemplary for one of the catchments. Additional changes in cultivation methods would be less efficient but would cause further reductions in particulate P inputs of 52 % in total and provide additional soil protection by reducing losses from source areas.