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Complexity of contrasting flow controls on phosphorus flux and transfer pathways

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Insights on hydrological processes from 'rain to stream' are important when interpreting the effectiveness of measures for reducing phosphorus (P) losses from agricultural sources to water bodies. A general understanding is that measures for management of P transfers along surface pathways will be consistently effective when applied on a whole territory approach. It is, however, necessary for policies to incorporate an understanding of spatial and temporal variation in hydrological flow controls, associated nutrient transfer pathways and chemical processes along the pathways. This variation is associated with variability in soil drainage, geology, climate and land management between hillslopes and catchments. In this study, four years of hourly stream P flux data from two Irish agricultural catchments were analysed on an annual and event flow basis. The analysis was related to hydrological flow paths in order to help develop a catchment scale (ca. 10 km2) theory of P export and associated processes that could help with specific P mitigation policies in heterogeneous river basin planning zones. A grassland catchment with mostly poorly drained soils and a 'flashy hydrology' had three times higher annual P flux than an arable catchment with mostly well-drained soils and a more buffered hydrology (1.04 kg total P ha-1 compared to 0.34 kg total P ha-1), despite the arable catchment having larger areas with high soil P status and more discharge. Neither of the catchments indicated P supply limitations. The magnitude of the P fluxes from the two catchments were not defined by land use, source pressure or discharge volume, but rather by a more basic rainfall-to-runoff partitioning which influenced the proportions of quickflow and slowflow. Despite the catchments having contrasting flow controls and P transfer pathways, there were larger differences in P loss between the years than between the catchments and the P loss from the arable catchment appeared to be more sensitive to weather. The results confirmed the need to manage the quickflow components of runoff to reduce P loss. However, the P transfer risk can be higher than the source risk and, in such cases, targeted schemes designed to attenuate diffuse P after mobilisation from soil surfaces should be considered.