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Assessing the role of colloidal phosphorus delivery processes in groundwater-fed agricultural catchments

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Soil colloids with high sorbing capacities can enhance transport of phosphorus (P) from soils to groundwater and the delivery of P to surface water via groundwater pathways. However, only particulate and dissolved P fractions are generally monitored at the catchment scale.

To add important insights into the particulate to dissolved P concentration spectrum in the soil-water environment, the role of colloidal P delivery processes to surface water was studied in two agricultural catchments. The catchments were dominated by belowground pathways but had contrasting land use (arable and grassland). Particulate, coarse colloidal (0.20 – 0.45 µm) and finer colloidal (< 0.20 µm) P fractions were monitored along hillslopes in the free soil solution, shallow groundwater and stream water on a weekly basis for background characterisation and at higher frequency during rainfall events. An automated sampler was deployed in the stream and an automated, low-flow and low-disturbance sampler was developed to sample groundwater. Multi-parameter probes were also deployed to monitor stream water and shallow groundwater physico-chemical parameters. Stream discharge was measured at high frequency using a flow velocimeter in order to quantify P loads, apportion hydrological pathways and study concentration-discharge hysteresis.

Preliminary findings showed higher background P and unreactive P concentrations in the stream and groundwater in the grassland catchment. In the arable catchment (rainfall event in June 2019) P was mainly lost through deeper baseflow (92% of the total event flow) as reactive P in the finer colloidal fraction (0.070 mg P/ha) and only a small fraction lost as particulate unreactive P (0.008 mg P/ha). In the grassland catchment (rainfall event in October 2019), P was mainly lost through quickflow (37% of the total flow) even tough deeper baseflow was also important (33%). Losses were mainly reactive P in the finer colloidal fraction (13.6 mg P/ha) but also as unreactive P (4.5 mg P/ha). Concentration-discharge hysteresis suggested a smaller and easily mobilised P source in the arable catchment and a larger P source, followed by the mobilisation of a second but smaller source via a second hydrological surface pathway in the grassland catchment.

Further monitoring campaigns during more rainfall events in the grassland catchment are

required to better understand colloidal P delivery and the spatial/temporal dynamics between rainfall events in relation to soil conditions and rainfall patterns. This will help to better target mitigations measures according to P species and fractions, hydrological flowpaths, and rainfall patterns – important in the context of a changing climate.