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Characterisation and quantification of phosphorus transfer in agricultural runoff through simultaneous monitoring at nested spatial scales

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Current data available for understanding and characterising nutrient transfer are generally collected at the catchment scale, where stream measurements integrate signals from upstream flow pathways. However, predicting and managing nutrient transfer at this scale requires a detailed understanding of the smaller scale processes and pathways which influence catchment scale data. This paper presents an original dataset which characterises and quantifies phosphorus transfer through simultaneous measurements collected at nested spatial scales (c.0.01 to 30.6 ha) within a small catchment. Monitoring took place in a mixed land use agricultural catchment in the UK between 2004 and 2006. Discharge was continuously measured on a five minute timestep, at five catchment locations: a flume fed by surface runoff (1.9 ha); three drain outfalls (1.9 ha, 2.5 ha and 3.7 ha); and the stream catchment outlet (30.6 ha). Water samples collected through five storm events were analysed for total phosphorus and total dissolved phosphorus, and were used together with discharge data to calculate phosphorus loadings and area normalised yields for the various flow pathways and scales. Data from the smallest scale, the unbounded hillslope patch (c.0.01 ha), where flow only occurred over the field surface during storm events, was collected using timed flow measurements and grab samples. The results show that phosphorus transfer within the catchment is extremely complex both spatially and temporally. In particular, variations occurred in phosphorus concentrations, loads and yields, and in the proportion of total phosphorus transported as dissolved phosphorus, between runoff pathways and scales and between storm events. The highest phosphorus concentrations were recorded in data collected at the hillslope patch scale (max. 12 mg TP l^{-1}), while concentrations at pathways representing larger scales were much lower; measured total P concentrations were below 5 mg TP l^{-1} in surface runoff at the field scale, below 1.5 mg TP l^{-1} in drainflow, and below 3 mg TP l^{-1}in streamflow. However, although concentrations were lower in drainflow and streamflow, phosphorus loads and yields were higher (up to 0.6 kg TP ha^{-1} in streamflow) than in surface runoff, as discharge through these flow pathways was much greater. Phosphorus transfer at the hillslope patch scale occurred almost entirely in particulate form, but at the catchment scale, where there was a significant baseflow contribution, dissolved phosphorus constituted around half of the phosphorus loss. These results will help provide an improved understanding of the processes and pathways controlling phosphorus loss at the catchment scale, and hence enable better prediction of nutrient loss and the design and implementation of appropriate management strategies to control diffuse pollution.