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Role of antecedent conditions on nitrogen and phosphorus mobilisation observed in a lowland arable catchment in eastern England: insights from high-frequency monitoring

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In order to reduce annual riverine loadings of nutrients which are responsible for degradation of ecosystems downstream and in near coastal areas, it is important to first understand the mobilisation and pathways responsible for transporting them from source to river and how these pathways vary in space and time. The Blackwater tributary of the River Wensum in Norfolk, England, has been equipped with a sensor network as part of the Demonstration Test Catchments project, which has the aim of reducing pollution from agriculture to river systems whilst maintaining food security by the trial of mitigation measures on working farms at the sub-catchment level. The River Wensum is a lowland chalk catchment with intensive arable agriculture and high occurrence of tile drainage on heavier soils. Three hydrological years of high-frequency data have been gathered in the Blackwater since October 2011, including rainfall, half hourly measurements of discharge and groundwater level coupled with hydrochemical parameters including nitrate, total phosphorus (TP) and total reactive phosphorus (TRP). In the three years of data collection, there were distinct departures from long-term rainfall averages as the winter of 2011-12 was extremely dry following a drought from the previous hydrological year, followed by a summer which was unseasonably wet, which continued into the following winter. The relationship between rainfall, storage and discharge was found to be complex, which in turn had an impact on the dominant controls transporting nutrients from the landscape to the river network. Thirty three storms occurred throughout the three year period which have been analysed in the context of the range of hydrometeorological conditions observed throughout the dataset. Discharge-concentration hysteretic responses of nitrogen, TP and TRP have been used alongside statistical analysis of storm characteristics including antecedent hydrological conditions. The nitrate storm response showed distinct seasonal patterns which were greatly impacted by the activation of tile drain flow throughout the winter period and during the fertiliser application window between March-May, with the dry winter in 2011-12 standing apart from the more ‘typical’ years. Four different storm response categories were identified for nitrate according to dominant flow pathways. The phosphorus response was far less uniform throughout the study period, showing patterns of exhaustion with successive events. Both nitrate and phosphorus loads were disproportionate to flow volume in storm events which occurred after significant dry periods. The data show the importance of antecedent conditions in the storage, mobilisation and transport of nitrogen and phosphorus in agricultural catchments which has important implications for the conceptual understanding of catchment functioning and environmental management.