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The effect of seasonal groundwater dynamics on nitrate export from lowland catchments

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Water flow and nutrient export from catchment systems is a dynamic process showing event-based and seasonal patterns. Since 1997 we study hydrology and nitrate export in the Pleistocene lowland catchment "Schaugraben" (20 km^2). Field data show strong seasonal fluctuations of in-stream nitrate concentrations, with highest concentrations (up to 140 mg/l) in winter and lowest in summer (nitrate free), correlating well with other seasonal variables such as temperature and discharge. Similar observations by other authors have been referred to temperature dependent denitrification and plant uptake. We suggest that the seasonal changes of nitrate concentrations are at least partly controlled by hydrological conditions: Groundwater concentration dynamics do not explain seasonal concentration changes in surface waters, as only weak concentration changes in groundwater were observed; stream nitrate concentrations are not related to temperature, as high nitrate concentrations were observed during high discharge periods in summer; groundwater level fluctuations result in connection and disconnection of tributary channels and nitrate polluted agricultural areas from the main stream. To study the hydrologic controls of solute export we set up a two-dimensional groundwater model representing a simplified catchment with a main and a tributary drain channel and two land use classes, grassland (between main and tributary channel) and agriculture (beyond tributary channel). A steady-state simulation based on average groundwater recharge and nitrate loads was compared with a transient simulation based on monthly lysimeter data. Groundwater denitrification was considered in a simplified reaction approach, assuming no denitrification (conservative transport) as well as first-order decay of nitrate based on half-life times of 2, 1 and 0.5 years. The results proof that seasonal changes of the flow system are a possible mechanism

explaining dynamics of in-stream nitrate concentrations at the catchment outlet. The connection of nitrate-rich groundwater via tributary channels to the main channel increased both, discharge and nitrate export. Sinking groundwater level disconnected nitrate rich areas from the main channel reducing total discharge and nitrate export. Assuming denitrification affected the concentration levels but did not change general concentration dynamics. The quantitative effect of this hydrological mechanism may be different in individual catchments depending on the stream and channel configuration and proportion of land use types. Temperature dependent denitrification processes or plant uptake may be superimposed to the hydrological mechanism, amplifying seasonal concentration changes.