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A multi-year drought can alter the nitrate retention capacity of a catchment

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From 2018 to 2020, large parts of Central Europe experienced an unprecedented multi-year summer drought with severe impacts on society and ecosystems. While strong reductions of water quantity were reported, our study is one of the first to analyze its impacts on water quality by looking at nitrate export dynamics in a nested mesoscale catchment in Germany with heterogeneous landscape settings. We used concentration-discharge (CQ) relationships to analyze catchment functioning in terms of nitrate retention and release, and the mechanistic process based mHM-SAS model (Nguyen et al., 2021) to simulate the underlying belowground nitrogen (N) fluxes and associated hydrologic transit times. For the three drought years, we found an amplification of the seasonality in nitrate export with lower concentrations in summer and higher concentration in winter, compared to normal conditions. Compared to the long-term average behavior, the catchment exhibited a disproportionally high annual load export relative to the discharge available for its transport. We argue that this loss in nitrate retention capacity was driven by a complex mixture of changes in N cycling and heterogeneous transit times among different contributing areas. During dry periods, long transit times and sufficient subsurface denitrification likely caused the low in-stream nitrate concentrations in the upper, more mountainous catchment, while reduced soil denitrification and plant uptake resulted in an accumulation of N in the soils. During the following wet periods, this accumulated N was rapidly exported to the stream (median transit times < 2 month) causing a steep increase in nitrate concentrations and load export. In the downstream (lower) sub-catchment, long median transit times (> 20 years) prevent such an immediate export of the accumulated soil-N to the stream. Our modeling analysis, however, suggests that the build-up of soil N-stores and the lack of fast, shallow flow path may exacerbate N legacies in the downstream part of the catchment, which might become visible as higher N export to the stream decades later. Hence, the more immediate concentration response to drought observed at the catchment outlet was dominated by the flushier upstream catchment. Overall, this increased temporal variability of nitrate export and intensified within-catchment differences caused by a multi-year drought call for a higher

spatiotemporal resolution of monitoring and more site-specific management plans for site-specific problems.

Nguyen, T. V., Kumar, R., Musolff, A., Lutz, S. R., Sarrazin, F., Attinger, S., & Fleckenstein, J. (2021, July 13). Disparate Seasonal Nitrate Export from Nested Heterogeneous Subcatchments Revealed with StorAge Selection Functions [preprint]. https://doi.org/10.1002/essoar.10507516.1