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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Nitrate sinks and sources as controls of spatio-temporal water quality dynamics in an agricultural headwater catchment" *by* T. Schuetz et al.

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Dear Dr. Reeves,

we appreciate the detailed comments made by reviewer #3. By answering the major comments we will present our thoughts and answers regarding the concerns raised by the reviewer.

Reviewer 3 Major comments

1. Lack of meaningful conclusions or utility of these data. I interpret the authors' primary conclusions as 1) both physical and biological processes affect nitrate concentra-

tion, and 2) these factors vary over time. The sentence on P8594 L12-14 is indicative of the limited utility of the results: "Consequently, the impact of certain sub-catchments on total nitrate export changes over time and the spatial changes can be more or less dominant." Despite the effort, I am not convinced these are novel or practical insights for research in stream biogeochemistry. To be complete frank, I found myself asking 'what does this add to our field?' at the point listed above, and at Pg8596 L5-10 and Pg 8597 L15-17. If the authors wanted to measure longitudinal patterns in 'hot spots' and 'hot moments' of N uptake, there are better methods for tracking nitrate than used here (e.g., isotope enrichment, stable isotopes, or N budgets). This would also offer better advice for restoration or planning (See next comment).

Answer

Apparently, we have to acknowledge that we have not pronounced clearly enough the main results and contributions of our study, which we will clarify in the revised manuscript accordingly: We did not aim at showing "only" "longitudinal patterns in 'hot spots' and 'hot moments' of N uptake", but we tried to show that it is possible to disentangle physical mixing and dilution processes from N-cycling processes (summarized in a simplified manner as Nitrate-removal processes (e.g. Basu et al., 2011)) and how both processes influence apparent in-stream concentrations along a headwater stream. (The relevance of first-order streams for total catchment nitrate export is addressed in the answer to Reviewer 2 Comment 1).–> See as well the answers to comment No. 5.

Basu, N. B., Rao, P. S. C., Thompson, S. E., Loukinova, N. V, Donner, S. D., Ye, S., and Sivapalan, M.: Spatiotemporal averaging of in-stream solute removal dynamics, Water Resour.Res., 47, W00J06, doi:10.1029/2010wr010196, 2011.

2. Little intellectual effect to explain or speculate on reasons for uptake 'hot spots'. The authors found that some reaches showed greater N uptake, but offered little explanation as to the physical, chemical, or biological mechanisms for uptake. In order for these

data to be useful in ecological restoration or planning as suggested (P8597 L20, as well as Pg8598 L12), the authors must provide greater interpretation as to the reasons for this pattern. Where there some aspects to the biology or geomorphology that the reaches had in common? As written, no speculation or interpretation is given, and therefore these data will be of little practical use.

Answer

We purposely did not focus in detail on the different biogeochemical processes possibly causing nitrate removal. We used the summarizing term nitrate removal, though we analyzed the interplay of water and nitrate flux contributions throughout the study catchment and how the spatial and temporal variation of water fluxes, nitrate loads and summarized in-stream processes cause the apparent in-stream concentration. We will add some sentences into the discussion on the spatial interpretation of the empirical measure of energy availability which we used to simulate in-stream nitrate removal. We think, that if we would have additionally analyzed how variations in stream-geomorphology, vegetation and other variables influence nitrate removal processes, the frame of the current paper would have been overloaded.

3. Overstatement of the meaning and magnitude of temporal patterns. The authors indicate this study represents an examination of 'temporal variations of nitrate contributions' (Pg 8593 L21). However, I suggest the authors temper this claim. The authors have measured N dynamics across a relatively narrow window of time, during static, base-flow conditions. From my interpretation, this time period was chosen to represent a 'static' environment (i.e., low flow, little precipitation) in order to minimize temporal variation among sampling campaigns. The authors should acknowledge that temporal variation which occurs over the annual scale would be much larger than the relatively small period included here.

Answer

The reviewer is right that the temporal variation observable between the different sea-

sons could be larger than the variations of nitrate concentrations presented within this study (We will add a sentence to clarify this issue). Nevertheless these variations occur during relatively short time periods (summer low flows) when ecological in-stream conditions are crucial for in-stream habitat conditions: e.g. a nutrient surplus in combination with warm temperatures and high solar radiation input can cause eutrophic conditions in the stream ecosystem. Hence, a better understanding of the evolution of apparent in-stream nitrate concentrations is relevant for e.g. water quality threshold exceedances (in contrast to other studies, where total annual nitrate loads are the relevant research-objects).

4. Restatement of objectives (P 8581 L21-24). I disagree with the wording of objective 1, and I disagree that the authors address objective 2. I suggest rephrase objective 1 as "Can we quantify spatio-temporal patterns of distinct nitrate sinks and sources in a stream?" I don't feel this is a network approach as only 1, small stream was considered. Also, I don't feel the authors measured 'impacts', but instead point out the spatial and temporal patterns. I suggest objective 2 should be deleted. The authors have determined the point sources of nitrate, and that these change with flow and over time. The authors have shown some reaches are N sinks. However, the authors do not determine 'mechanisms and processes' for N sinks (see major comment above), which would require additional biological measurements.

Answer

We propose a rephrasing of objective 1 as follows: "Can we quantify the spatio-temporal impact of distinct nitrate sinks and sources on nitrate dynamics in a first-order stream network?" The stream network we studied consisted of a first-order stream, one surface tributary and 11 subsurface tributaries (drainpipes). This setup can be interpreted as a small stream-network. The scale of our study-catchment (1.7 km^2) is a common size for hydrological research catchments, where e.g. the spatial variability of hydrological processes regarding stream water composition (e.g. hillslope hydrology) is studied. In our answer to reviewer #2 we discussed already the relevance of first-

order stream networks to the regional stream network. Regarding the second objective we disagree with the reviewer. Instead of focusing on biogeochemical drivers of nitrate sinks and sources alone we include and analyze the spatially and temporally variable impact of water fluxes (i.e. different catchment sub-storages) as well. We will add a sentence in the discussion that we do not use the presented approach to distinguish between different biogeochemical processes but to empirically simulate the net effect of different biogeochemical processes on downstream nitrate concentrations.

5. An acknowledgement: I must be candid about my lack of experience with the dilution calculations offered by the authors. I followed the authors' logic, but it is not a tool I have used. Thus, I do not offer detailed critiques on these calculations or derivations and will rely on other reviewers to provide those comments.

Answer

Unfortunately, this acknowledgement concerns the crucial contribution of this paper: The detailed observation and quantification of nitrate AND water fluxes (which are usually NOT determined explicitly) with field measurements and the mixing-model throughout a first-order stream network allowed for quantitatively distinguishing biogeochemical and mixing/dilution processes. For example on Reach 4 at our study site we observed a concentration decrease which was caused by dilution and not by removal processes. On the scale of an entire headwater catchment this interplay of mixing and removal processes have not been discussed in detail in other studies (excluding explicitly pure modeling studies!)

Reviewer 3 Specific comments

Pg8578 L14. Correct to "nitrate" (avoid the incorrect plural term 'nitrates'). Will be changed accordingly

Pg8580 L25. Remove ". . ." in parenthetical phrase. It is better to be specific or use "e.g.," for a short list. Will be changed accordingly

Pg8582 L 10-12. Edit ". . .decreasing. A nitrate source does not necessarily increase stream nitrate concentration, but always increase total nitrate load." Will be changed accordingly

Pg8583 L9. I am confused by the last sentence of this paragraph. By 'prevents almost completely discharges losses during summer low flows" do the authors mean there is little infiltration? The reviewer understood this right. We will clarify this sentence in the revised version of the manuscript.

Pg 8586 L24. The first sentence of section 3.3 is very long. Is there a period missing? Please revise into separate sentences to increase clarity. Will be changed accordingly

Pg 8590 L 25. This paragraph about slope, roughness, and residence time calculations would be more appropriately placed in the methods. Will be changed accordingly

P 8592 L10. Delete "time variant" as the sentence already indicates spatial and temporal distribution. Will be changed accordingly

Pg 8596 L 27-28. This claim is an overstatement and incorrect. There is a vast literature on spatial and temporal patterns in N concentrations and transformations. We do not neglect previous studies on spatial and temporal patterns in N concentrations and transformations (we promote this type of research in this study, hence it is not our purpose to neglect it), but the body of literature focusing on observations made at the catchment outlet is comparably dominating. -> We will change the word "most" into "many".

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 8577, 2015.