

Reviewer comment to Arendt and ten co-authors on: High temporal and spatial nitrate variability on an Alaskan hillslope dominated by alder shrubs

The topic of the study to investigate the N cycle, in particular shifts in the nitrate concentration in the soil pore water in permafrost soils, affected by the N₂ fixation of alder (*Alnus viridis* ssp. *fruticosa*) is generally interesting. However, the study and the structure of the article has some major flaws and is a listing of observations instead of presenting a study with a clear focus. The structure of the article may be improved, but -unfortunately- several limitations of the design of the study cannot be corrected anymore (in retrospective).

Aspects to can be improved:

Many aspects that emerge in the result section, are not adequately described in the M&M section. Some descriptions given in the Supplementary Material

- “Seep” has not been explained in M&M
- Patch of *Alnus* shrubland: dimension/ size of the patch not defined. Valuable pieces of information would be height of bushes, density of alder branches per m². Please add.
- Authors present the total numbers of measuring points or samples (including soil pits), but it remains unclear what is really a replicate; a transect contains how many measuring points? The structure of the measuring points is also key for the statistical analysis. Both, temporal and spatial variability has to be taken into account in the statistical analysis. Here, one gains the impression, that one and then the other has been lumped together. To emphasize that non parametric versus t-tests have been used is not adequate here.
- The term “*Alnus* savanna” simply does not exist and is misleading, please remove this term throughout the whole text!

Flaws in the design (cannot be corrected anymore)

- The nitrate concentrations in soil pore water of *Alnus* shrubland along the hill is compared to those in the soil pore water in the lowland. However, authors stated that the soil was partly covered by standing water and the alder bushes were much smaller in the lowland area or do not even exist in the lowland (Figure 4!) So, standing water on one hand may dilute the nitrate concentrations and create denitrifying conditions, and on the other hand smaller *Alnus* shrubs have for sure a lower N₂ fixation. These two aspects cannot be disentangled. So, it is obvious that the nitrate concentration is lower under such conditions, described here as major result (please avoid overstatements in general). Furthermore, it has already been shown that the nitrate concentrations in the soil water under *Alnus* stands is much higher than under non-*Alnus* stands due to the N₂ fixation (not a new result!)
- On site weather station is fully missing. Although authors stated precipitation events as key for leaching processes.
- A measuring campaign during 4 days (year 2017) is simply not representative for a seasonal measure (overstatement).

Detailed comments:

Abstract: Line 11: in the Arctic with capital letter, but arctic ecosystems with small letter. Please adapt throughout the MS.

Line 13: Simply not true, please consult the literature and adapt

Line 14: Edaphic controls for the nitrate concentrations has not been shown.

Line 18: I do not agree that all the nitrate is produced by degradation of N-rich alder shrub organic matter...or depends on your definition of organic matter..Are the corolla structure of the alder roots/nodules where the N₂ fixation takes place, organic matter (I think not!)? The majority of the nitrate is already released during the N₂ fixation.

Line 19, etc.: In general, better to express the nitrate concentrations as nitrate-**N** (enhanced comparability to other N compounds, atmospheric N deposition)

Line 23: denitrification buffers nitrate mobility. Strange description! Nitrate is transformed into N₂ (complete) or N₂O (incomplete) denitrification. From an ecological point of view the production of N₂O is worse than nitrate mobility! Please adapt.

Line 24. Nutrient production is a misleading term. Through N₂ fixation nitrogen as a nutrient gets available, then it is transformed or lost again through complete denitrification..please adapt.

Line 40: Nutrient availability instead of nutrient production

Line 46: Latin names - italic

Line 48: instead of microbes, add here: *Frankia* bacteria

Line 51, line 57: Wrong!! Brühlmann et al. 2014, Hiltbrunner et al. 2014: Both studies are located in the montane (not in the alpine vegetation belt of the Alps), but clearly not on permafrost soils! Increase of alder shrubland due to changes in land use, not increasing temperatures. Please correct and add this aspect of land use changes.

Line 68-70: Necessary?

Line 73-76: Hypotheses rather weak as already widely known that alder shrubs through their N₂ fixation are source for nitrate. And your measuring campaigns cover some days in July and September, not seasons. And see comments on line 18 and 23 (comments are not repeated here).

Line 80: unusual format for coordinates, add elevation of the KG hillslope, please adapt

Line 95ff, add species names of the dominant species of graminoids and dwarf shrubs.

Line 101-112: rather unclear and wordy description. Be more precise here! Avoid expression such as initial phase and comprehensive informed phase (rather empty expressions).

Line 114-135 unclear what means additional transect here, how many sampling points per transect?? Shorten! Please be more precise.

Line 140ff: a nest of macro-rhizon: please define in the main text (not in the Supp. Material)- I wonder how long lasted the installation, for such short sampling intervals (of 4 days) the installation duration may affect the water sampling of the first day. Please explain!

Line 167. Unclear description, which transect (?) and soil 0-15cm has not been sampled?

Line 180: Why five litter samples when A1 and A4 have three sampling locations each, unclear...

Line 184: instead of each water sample...*In situ* parameters were measured for each water sampling location ...

The whole M & M section needs to be strongly streamlined, now it is a potpourri of very different measurements and reader often does not know why for what purpose a measurement was carried out, besides when and how many times...I suggest to present all these different locations and campaigns in a Table.

Line 191-203 Statistical analysis: Weak description, no information how normal distribution, outliers, etc were handled. Weird description of processes acting on nitrate production.

Line 205: I assume that soils (and correspondingly patches) along the slope differ from soils in the inundated lowlands. And permafrost occurrence and thickness of the layer- were they similar along the hillslope as in the lowlands? Please specify!

Line 208: personal observation of whom? Mean gravimetric soil moisture content

Line 209: unclear: which other sampling campaigns?

Line 212: what are logistical and sampling challenges? Unclear.

Line 213: adapt subtitle, 4 measuring days do not allow to delineate synoptic results (overstatement)

Line 214: you mean.. nitrate concentration was higher ... please adapt

Line 216: Strange description on atmospheric condition, air temperature, mean or maximum , please be precise, brief precipitation event, add where this has been measured and the exact rain amount.

Line 220: Seep? Not introduced in M& M.

Line 221: relative to the other three sampling days in July

Line 222: avoid such blue sky interpretation! Adapt

Line 224: 58.61 mg L⁻¹ Typing error, such high values are not presented in the Figures nor in Tables!

Line 230: please describe the weather conditions during your campaigns properly

Line 234-237: two times the same results with very different outcomes? Rather weird description, please improve.

Line 228-258: Not fully clear what you like to present as results here, rather repetitive description on the different campaigns, not really convincing, please improve

Line 259-271: Rather a potpourri of observation, in M &M section you mentioned 5 litter samples, now there are 10. What do these results tell you.

Discussion: Obvious that the N₂ fixation is the main source for the nitrate! So, please reorganise the whole discussion, now it reads like another result section! Please adapt

Line 325-326: what kind of additional controls? Please avoid such empty sentences.

Line: 329: A new aspect emerges: the comparison with the global meteoric water line! Why do you expect evaporation ins such a wet landscape? See line 244 Water flows even during periods without rain...

Line 386: Future research? Rather bizarre that the authors list all the requirements for a more solid study. I would not declare these points as future research but as prerequisites for the current study!

Line 401: Really unclear how such a single hillslope study should be of value for ESM

Line 4902: bolster??

Conclusion: Already established that alder fix atmospheric N and therefore contribute to higher nitrate concentration in soil water. Rather redundant conclusions.

Figures

Figure 1 (a) better to insert a map

Figure 2 a, b: Redundant to use different size of symbols and different colours. Please use for the same nitrate concentration the same colour! It is not really convincing to present means AND single values

Figure 3: add sd (of bars) and add weather conditions (at least air, soil temperature and rain in mm)

Figure 4: There are no alders in the lower part of both transects, correct? I have some doubts whether the log Y scale really helps here. Table with the values (mean \pm sd, number of replicates would be for sure more informative)

Figure 6. Boxplots largely overlap, that means no significant differences. How did you get this $P < 0.05$? Though single t-tests? (Multiple mean test would be correct). Add n here...