

“Predicting long-term denitrification capacity of sandy aquifers from incubation experiments and sediment properties”, by W. Eschenbach and R. Well

This manuscript presents results from ex situ incubations to determine the long-term denitrification capacity of two sandy aquifers. The relatively large dataset and conclusions have important implications for local water resource management and pollution control. Furthermore the manuscript provides a framework for further attempts to predict long-term denitrification capacity with relatively small effort (short-term incubations and sediment parameter analysis). I recommend its publication in *Biogeosciences*. However, I have a few questions and concerns.

General concerns

Generally, the authors should make clear from the beginning what the limitations in their method are, e.g., ex situ incubations for predicting in situ rates; one year incubations for predicting several decades etc.. Maybe already in the title the misleading “long-term” should be replaced.

Another major concern is that the authors focus on organotrophic and sulfide-dependent denitrification only. However, there are other electron donors such as Fe(II), Mn(II) or ammonium. How would for example anammox (the anaerobic oxidation of ammonium) influence the results? What is the potential for this process in the two examined aquifers? How can the authors predict how much ammonium will be available in the sediments in the future? E.g., coming from organic matter remineralisation?

Finally, the authors did not address the possibility that nitrate could be reduced to ammonium (DNRA) by e.g. sulfide oxidation. This pathway would result in partial N recycling, and in a significant electron donor loss.

Specific questions and comments

Page 8808. Line 25. Are the authors that confident that D_{cap} (= Denitrification capacity during 1 year) can always be predicted by short-term incubations and sediment analyses? At least, the results presented in this study do NOT prove that the long-term denitrification capacity can be predicted. The sentence should be rephrased to e.g., “We use our results from short-term incubations and analysis of sediment parameters to predict the long-term denitrification capacity of a sandy Pleistocene aquifer.” Or: “In our study, D_{cap} of two sandy Pleistocene aquifers was predictable using a combination of short-term incubations and analysis of sediment parameters.”

Page 8810. Lines 5, 17, 18. “organotrophic” instead of “heterotrophic”.

Page 8810. Lines 6, 7, 13, 15. “lithotrophic” instead of “autotrophic”. (The correct scheme is: hetero- vs. auto- in terms of carbon substrate used for growth; and organo- vs. litho- in terms of electron donor.)

Page 8811. Line 19. “...calculated a maximum...” instead of “the”.

Page 8812. Line 2. Write “... from actual in situ rate measurements using...”

Page 8812. Line 3. I don’t understand. (c) was a goal (as stated above) but is not addressed in this study?

Page 8812. Line 21. “is” instead of “has been estimated”.

Page 8812. Line 23. “Evidence for intense ongoing denitrification...”.

Page 8812. Line 26. “organotrophic” instead of “heterotrophic” if you speak about electron donor.

Page 8813. Line 1. “lithotrophic” instead of “autotrophic”.

Page 8813. How much time passed between sampling and the start of the incubation experiments? Also state in what year and month the cores were drilled.

Page 8814. Line 8. What is the natural range for nitrate concentrations in the 2 aquifers?

Page 8814. Line 8. Does that mean 60% $^{15}\text{N-NO}_3^-$ and 40% $^{14}\text{N-NO}_3^-$? And where was the ^{15}N material from?

Page 8814. Line 9. How do you know it was airtight? What kind of rubber septa were used? Were they made anoxic before use (as e.g., described by Canfield et al. 2010)? Most stoppers are not completely oxygen-tight, which might be significant if the incubations take as long as 1 year. Did you check for oxygen contaminations in your incubations?

Page 8814. Line 14. “... for up to one year...”

Page 8814. Line 22. 13 ml gas was transferred into 12 ml exetainers?

Page 8815. Line 15. “... to check for possible denitrification...”

Page 8815. I understand that the “intensive treatment” experiments were conducted to speed up electron donor usage. Can you add a reference why and how much this is faster at 20 C? And please explain in a sentence why adding quartz sand.

Page 8815. Line 26. “were” instead of “where”.

Page 8816. Line 11. Delete “to SO_4^{2-} ”.

Page 8816. Line 24. What masses were measured on the IRMS? Although you cite Well et al., please give a brief explanation of how you determined total N₂ production in your incubations.

Page 8820. Line 15. What was the minimum nitrate concentration to be considered “nitrate-bearing”?

Page 8820. Line 22. 1.5 mg O₂ L⁻¹ is quite high for being called “sulfidic”...

Page 8828. Line 17. Spell “denitrification”.

Page 8828. Line 20. Rephrase this sentence.

Page 8832. Line 11. “were” instead of “where”.

Page 8833. Line 23. Remove brackets around citations.

Page 8835. Line 12. Delete “high to very high and”. Or what do you mean by “high to very high and highly significant”? The correlations are just highly significant (no matter whether p<0.001 or p<0.01).

Page 8835. Line 20 to 23. I do not agree with the conclusion, that the bioavailable fraction of C_{hws} is higher in the upper part. The non-correlation between C_{hws} and D_{cap} in the sulfidic aquifer might simply be because denitrification and thus D_{cap} is sulfide-dependent in this region.

Page 8836. Line 23. “were” instead of “where”.

Page 8838. Line 20. “too short” instead of “to short”.

Page 8840. Line 4. Change this title to e.g., “Are laboratory incubation studies suitable for predicting in situ processes?”

Page 8840. Line 15. “within the range” instead of “between”.

Page 8841. Line 8. “Decreasing concentrations” instead of “A decreasing concentrations”.

Page 8841. Line 17. Spell “investigated”.

Page 8842. Line 25. “were” instead of “where”.

Table 3. Is it necessary to distinguish between p<0.001 and p<0.01?

Figure 1. Please add a legend (open symbols, closed symbols, crosses) to the figure. Also consider using black as the fill color. As the figure is now it is hard to distinguish between open and closed symbols.

Figure 1 caption. “denitrified” instead of “denitrified”.

Figure 2. What does A, B, a, and b stand for?

Supplemental material: A map indicating the sampling locations would be helpful.

Also show e.g., nitrate concentration decreases during your incubations. Does the amount of nitrate consumed fit with N_2 production?

References

D. E. Canfield et al. 2010. A cryptic sulfur cycle in oxygen-minimum-zone waters off the Chilean Coast. *Science*. 330: 1375-1378.