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Biogeosciences Discussions

Interactive comment on "Sources, fate and geochemical dynamics of nitrate in an oligotrophic lake" *by* U. Tsunogai et al.

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Dear Prof. Gardner,

Thank you very much for your comments on our manuscript. We are encouraged by reading them. We would like to reply to you by citing each of your comment.

>1. The most important issue, in my opinion, is that the pivotal role and importance of ammonium dynamics in relation to nitrate biogeochemistry is not emphasized sufficiently in the paper or in the conceptual model that is presented. For example, the schematic diagram presented in Fig. 6 does not even include ammonium as a crucial component but implies that organic nitrogen is converted directly to nitrate. My understanding of the mineralization process is that organic nitrogen is not mineralized directly

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Interactive Discussion

Discussion Paper

to nitrate but is mineralized to, or excreted as, a reduced nitrogen form (usually ammonium) before being taken up by phytoplankton (or N-starved bacteria) and/or converted to nitrate. I do not know of evidence indicating that reduced organic nitrogen is mineralized directly to nitrate as implied in the figure and parts of the text. Essentially all nitrate produced internally in the lake must have been regenerated first as ammonium so inclusion of ammonium dynamics is crucial to understanding the internal cycling of nitrate. Also, much of the ammonium that is produced in surface waters may be takenup by phytoplankton directly without being nitrified by bacteria/Archaea. Regardless of the mechanism, the authors' observation of low levels of inorganic nitrogen in the euphotic zone of this oligotrophic system makes sense because phytoplankton can assimilate available nitrogen in either form. To the authors' credit, they say that ammonium dynamics should be examined more thoroughly, but my point is that ammonium dynamics is critical to the model they present and should be discussed conceptually, whether or not it was measured directly. I.e., the model presented in Fig. 6 and the text should include ammonium dynamics to give the reader a more realistic picture of what is going on with regard to nitrogen cycling.

We don't think organic nitrogen was remineralized directly to nitrate either. Most of them must be remineralized to ammonium and then being taken up by phytoplankton and/or converted to nitrate. We would like to add ammonium in Fig. 6, as well as its possible dynamics in the lake.

We certainly agree with you for the importance of ammonium dynamics within the nutrient dynamics in lakes including such oligotrophic lake. At present, however, little have clarified in the lake. We would like to add several sentences to emphasize this, as suggested.

>3. The results of this paper show strong resemblances to those found in Lake Superior, another cold and oligotrophic lake, and the authors make some nice comparisons with previous publications on gas exchange in Lake Superior. However, I believe that it would be useful for them to also compare their results with some previous papers

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regarding internal nitrogen dynamics in Lake Superior. Their ïňĄnal conclusions about the fate of nitrate and much of their conceptual model seem strikingly similar to those made by Komar et al. about Lake Superior (see references below) using completely different methodologies. I suggest that the authors incorporate some of the concepts presented in those papers into the current manuscript as I believe that it would strengthen the ideas and conclusions of both investigations.

Thank you for the suggestions. We would like to add following reference to compare the results of lake Mashu with lake Superior, as well as to emphasize the resemblances between them.

Kumar, S. et al. 2008. Nitrogen and carbon uptake dynamics in Lake Superior. JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 113, G04003, 15 PP., doi:10.1029/2008JG000720

>Question: Page 7233, second paragraph. How long were samples stored in refrigerator before analysis?

The maximum storage was two months. We would like to add these in the revised manuscript.

>Small grammatical details: In several instances, including the first sentence of the abstract, I think the writing would be improved by reversing the order of presentation of phrases in the sentences. I.e. start that sentence as “The stable isotope compositions of nitrate, including the 17O anomalies (∆17O), were determined twice in one year (June and August 2007) in the water column of Lake Mashu, Japan, to trace the fate of atmospheric. . ...” Same idea for second sentence of last paragraph of page 7235, first sentence of last paragraph of page 7236, the last sentence of the first paragraph on page 7233, the last sentence of the second paragraph on page 7238, and the second sentence of the second paragraph on page 7241. Page 7230, first line. Insert “ammonium and converted to” after “remineralized to” Page 7242, second paragraph, first line. Replace “was” with “occurred” Page 7244, last paragraph. Should not “reducing”

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be replaced with “subtracting”?

Thank you for your suggestions. I am sorry to bother you for them. We would like to revise all the points as suggested.

>Overall, I find the paper to be innovative and interesting and recommend that it be accepted for publication after minor revisions.

We would like to thank you for the helpful comments and suggestions. We trust that the answers are satisfactory responses to your comments and questions.

Sincerely, Urumu

Cc: S. Daita, D. D. Komatsu, F. Nakagawa and A. Tanaka

Interactive comment on Biogeosciences Discuss., 7, 7227, 2010.