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Interactive comment on "The relative importance of photodegradation and biodegradation of terrestrially derived dissolved organic carbon across four lakes of differing trophic status" *by* Christopher M. Dempsey et al.

Anonymous Referee #1

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The manuscript presents a very interesting study aimed at discerning processes within lakes that control the mineralization of DOC, whether biodegradation or photodegradation prevails. It's an important contribution to the field to quantify the possible load of CO2 emitted from lakes, in the current scenario of climate change, and studies in this respect are highly valuable. Moreover, studies addressing in-lake DOC processing as both biodegradation and photodegradation are scarce. Therefore, this manuscript is a timely contribution to this area of research. The manuscript is well written and despite being easy to follow it is not trivial, but instead of a high scientific soundness.

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The aims are well described, the abstract is informative and well resumes the study. I have some comments that are highlighted below, and I recommend to consider, in the discussion, mechanisms of primary production in lakes and DOC lability, as this may be related to the different biodegradation response. Overall I enjoyed reading this manuscript and I would like to see it published after some revision, as suggested by the following comments.

Introduction

84: I would suggest to add a few words clarifying mineralization, degradation, respiration

95: Just a guess but in the Arctic it might be that the low temperatures slow down bacterial activity and therefore, photomineralization prevails. I think it really depends on other bio-physical factors and external climate conditions, could you provide other examples?

97: why does the source of inland water CO2 remain uncertain? What are the possible explanations besides bacterial activity and photomineralization?

104/105: I would talk a bit more on CDOM, giving some more information. As it can represent a great portion of DOC, I think it is a bit reductive to refer to it only as “absorbance characteristics”.

107: do you mean the smaller MW, the less attenuation by DOC because of larger molecules? Or do you mean that light can make DOC otherwise unavailable to bacteria, available? Eg. Kieber et al., Nature 1989 (referred to marine systems, but could be probably applied to freshwater environments as well).

111: in this study, does sunlight-driven degradation accelerate subsequent bacterial activity?

115-119: this sentence is very long and hard to follow. Could you break it up into two sentences or rephrase it?

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125: when you say reactive, do you mean easily broken down/degraded/uptaken by bacteria?

126: different optical properties how? Can you specify?

Methods:

183: can you specify why groundwater can be a proxy for terrestrial DOC runoff? I have seen it afterwards in the discussion but I would just add a few words here as well.

209: additionally to the 3 treatments, did you also check for combined photodegradation + biodegradation setting or would it have been too tricky to discern which process from which in that case? Maybe it could be some experiment to try in the future. What are possible limitations? You could add a few sentences in the discussion about that, if it's a feasible experiment.

239: why did you inoculate the samples with GW only for the biodegradation experiment? Would it have been interesting to see the short-term response of photodegradation too, and check which one could be faster or prevailing? Just asking for curiosity.

255: what was the temperature of the Lacawac Lake in the experimental months compared to each other lake, singularly? Was there a high difference?

277: I would explain better the meaning of Sr: how do you calculate it and that it increases with photodegradation, thus its increase is inversely related to MW. What about its relation to biodegradation instead?

299-308: it would be easier to see if presented in a suite of equations/formulas.

314: As "seasonal response" do you mean the monthly differences? June July and august seems more similar in DOC response compared to May in Lacawac lake. Could it be because of temperature? (Fig S3). It seems to me that brown water lakes with higher GW DOC background showed a more variable response. Were there any significant differences among different months?

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377 and Figure 1: it seems that biodegradation mostly affected DO concentration with respect to control with no evident differences between the lakes, while it didn't change much for DOC, DIC, SUVA and Sr. Why do you think the losses of DO due to photodegradation were higher with respect to biodegradation? Again, do you think temperature may have played a role? Together with light there must have been an increase in temperature in all samples exposed to light. This could not be much evident, probably, in the biodegradation samples (slighter differences among lakes). In general T increases bacterial activity and therefore DO loss. Is it possible that lakes with higher load of particulates may have experienced higher temperatures and therefore, more changes in the DOC and DO?

Discussion

487 and 493 (DOC and DO): It seems to me that where the DOC background is lower (eutrophic and oligotrophic) the bacterial response is higher. Could the higher DOC be the result of a bacterial turnover of carbon, producing different DOC over previous substrates? If looking at Sr, Gilles and Waynewood have the lowest values, possibly indicating a production of DOM of higher MW with respect from starting compounds. Maybe the differences seem minimal but if changing the scale in figure 1e for the biodegradation part, possibly differences are more evident. Maybe you could check with S (e.g. 275-295) or CDOM absorbance to further investigate into that process, whether it could actually be a bacterial contribution. I may think that in general, where the DOC background is lower, the partially photodegraded DOC is extremely easy to be processed and taken up by bacteria, therefore it's harder to detect it. In your samples you may not see this mechanism because samples exposed to photodegradation excluded bacterial activity by setup and viceversa, but if I understood the setup right, it may be that that the photodegraded fraction in the biodegradation experiments might have quickly been assimilated by bacteria already in situ (i.e. in the lake at samples collection), remaining with a fraction to be processed and a large unprocessed fraction. Thus, complex substrates need light as a catalyst for further bacterial assimilation. And

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time can also explain this process, the turnover rate for bacteria is longer than for light, depending on the complexity and reactivity of the starting material. Some more argumentation should be added in this respect (see comment below as well).

501-503: this is very interesting. Why do you think this mechanism occurs? How can it be related to primary production and the release of “fresh” and labile DOC that bacteria can assimilate more easily? I think some argumentation should be added here, and I believe it would be very useful to discuss about different carbon fractions and reactivities (labile, semi-labile, refractory)..

520: although for marine systems, I think here Kieber et al. 1989 could be added as a reference https://www.nature.com/articles/341637a0

547: it joins to my previous comment (501-503): “microbially derived” should be better explained as bacteria may channel a great portion of DOC produced by autotrophic organisms.

559: I suggest to better explain this concept: the more DOC the more DIC produced?

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