Interactive comment on "Quality transformation of dissolved organic carbon during water transit through lakes: contrasting controls by photochemical and biological processes" by Martin Berggren et al.

Anonymous Referee #1

Received and published: 10 August 2017

GENERAL COMMENTS

In this paper, the authors test the hypothesis that coloured dissolved organic carbon (DOC) would be selectively lost in boreal lakes, following previous observations from large-scale studies. Based on field and lab data, they found that at the individual lake scale, DOC loss is largely dependent on ambient DOC color (a_{420}). They found that colour loss occurred in clear water lakes, whereas in brown water lakes DOC colour remained sustained over time.

These results have relevant implications for current debates about the role of lakes in carbon cycling and DOM processing, within the aquatic continuum as well as within the landscape, and therefore I strongly suggest this paper for publication. Findings of this paper are based on a complete data set that includes a large temporal period (7 years in Björntjärnarna catchment, as well as 3-4 years in 7 additional lakes) as well as a reasonable regional representativity of lakes with varying DOC and water transit time (WTT) conditions. The latter nicely showed how the "browning" level of lake water may be a main factor determining DOC reactivity within a lake. The authors argue that this factor may even overrule the effects of hydrology, even though I will partly question that below.

Unfortunately the authors did not explore the temporal perspective of their data set, as they pooled all the different sampled time points under a regression analysis approach. Showing some time series, even if it is in the supplementary material, would add completeness to the study; and may support some speculative paragraphs of the discussion, as I comment below.

Here follow some specific comments which I hope may help to improve the manuscript:

SPECIFIC COMMENTS

2.4 Water transit time assessments

P5, L 7: "The transit time, represented by the water that resides in a lake at a given moment, . . ." A time that is represented by a water volume sounds confusing. What about "The transit time of the water volume that resides in a lake at a given moment, . . ."
P5, L 9-10: It would help to add units of Voltotal, Flow rate and WTT.
This section describes the calculation of WTT values for epilimnion, hypolimnion, and inlet sites, but not for outlet, even though this data is later used in Fig. 1.

2.5 Response variables

P6, L 26-29: Is this a specific finding of this study, or from a previous study?

P6, L 23: "Besides DOC and a_{420}..." add mention that a_{420} is an indicator for DOC color plus associated reference(s).

2.6 Laboratory experiments

This is the part of the paper I am less convinced of. These lab experiments, as standardised procedures, may be useful to compare the DOM reactivity from different sites/lakes, however I think their comparison with field data should be done with much care.

Dark experiments: I wonder how representative it is to incubate water for 15 months compared to what happens in the lake, where both the DOM and the bacterial community are continuously mixed with newly arrived molecules and cells. During these 15 months, did you check/control for nutrient limitation?

P7, L 26: "higher than in the dark control incubations": should it be without "control"? (no control was mentioned for the dark incubations).

P7, L 29: At the end, I suggest briefly mentioning that the measurements before and after the incubations were used to calculate the "change" in DOM properties (as it is later used in the results), and how this was calculated. May I point here that different units are presented in Figs 3 and 4.

2.7 Statistics

P8 L 5-7: Is there a reference to support this? Also, in order to evaluate the significance of the linear regressions, I strongly suggest the additional use of the R^2 (it is presented for the Björntjärnen lakes but not for the survey lakes regressions).

3.1 Björntjärnarna chain lakes and Fig 1

Fig 1. The colours between Inlet stream and Övre Björntjärnen epi are almost indistinguishable. However, here I wonder about the inlet and outlet sites. First I wonder if

it makes sense to add the inlet points to the analysis, since it is not affected by what happens in the lake. And about the outlet, I wonder to what WTT it is assigned to, since in the methods there is only a definition for the WTT of epi and hypo and inlet.

P18 L 3-4: This may not be needed, since the y-labels are already shown in the plots, and the variables described in the methods.

3.3 Survey lakes and Figs 2 and 3

In Fig. 2, the authors argue that there is a differentiated behaviour between brown-water lakes and clearer-water lakes. Even though this is later very neatly systematized in fig 3, I suggest adding this information somehow already in Fig 2, to help relate the plot with the description in the text. One suggestion would be to draw the lines in a colour indicating the corresponding DOC concentration, or a_{420}, as reported in Table 1. This would also allow seeing if any two lines of epilimnion and hypolimnion are paired.

On the other hand the two groups with opposite slopes, not only correspond to clear vs brown water lakes, but also they have very different ranges of variation of the WTT. For example, in Fig 2A, those lakes with negative slopes are also those with shortest ranges of variation of WTT. So here it is fair to wonder to what extent the slope is a statistical artefact resulting from the data not covering a similar range of variation. In fact, if all lakes were pooled together, the relationship between a254:a365 would be positive (we do not see the points in the graph, but I am joining the regression lines), and the same can be said for the other panels (if all points were to be pooled together, they would follow the trend described by those lakes with larger WTT ranges). With this I do not mean to invalidate the results, but maybe some more information could be added in order to emphasize the validity of these correlations, like adding the R^2, or plotting their corresponding data points to evidence a clear linearity. I think it is important to solidify these results, as later they lead to intriguing interpretations like DOC concentrations increasing with longer WTT.

An interesting result that can also be drawn from figs 2-3, is the fact that those lakes

with intermediate colour levels are less responsive to changes in WTT (slopes not significant). This would imply that this kind of lakes are less sensitive to hydrological variability and therefore less affected by hydrological events like rainfall or drought. This could also be mentioned/discussed in the text.

3.4 Experiments

P 9 L 25: "similar to the changes observed over time" according to the caption of figure 3, it is not a variation over time but as a function of WTT.

3.5 Overall color loss

P9 L 29-30: "we multiplied the in situ rate of epilimnetic color loss in the survey lakes (same as slopes in Fig 2d) with the mean water transit time for the respective sites to find out how much total change there was in water color upon transit": I do not understand how this becomes a percentage of color loss, I suggest that this is more explicitly stated.
Then, this "relative color change" is compared with the percentage change in the experiments. The calculation of the latter is never explained in the text, I suggest briefly explaining that.

Discussion

P10 L16-21: I think it should be taken into consideration here that the brownest lakes also had much shorter ranges of variation of WTT.
P10 L 23-31 With the data set you have, including 3-7 year time series, you would not need to speculate about that. Why not just check how a_{420} and DOC change over time, or seasonally, in the inlet and outlet of the Björntjärnen lakes?

Conclusions

P13 L 2 "brown headwater lakes": or just "brown-water lakes"?
P 13 L 4 "Thus change in WTT, e.g. due to a potentially wetter future climate, has no

universal effect on lake color": This is a too hard statement, considering that your data for brown water lakes only covered a small range of WTT values.

TECHNICAL COMMENTS

Some suggestions, even though I am not a native English speaker:

P2, L 26: ". . . as a result in temporal . . .": as a result of temporal
P3, L 1: "selective" instead of "selected".
P3, L 6: ". . . and analysed using linear mixed effects regression" probably not necessary to be mentioned at this stage. If it is mentioned, though, it should be stated what the mixed effects regression was for.
P5, L 8: "that passes by" not necessary.
P7, L 30: "The response of" instead of "The response in"
P7, L 3-4: "goes up" and "goes down": may I suggest avoiding these. Maybe that could be replaced simply for "If this ratio increases with WTT. . ." and "but if a_{420}:DOC decreases. . .".