Prijac A. 2022 . Biogeosciences

Overview:

This paper presents a large and detailed investigation of DOC concentration and composition in peat porewater and pools in a pristine peatland in northern Quebec. The dataset is interesting.
As clearly stated in the title, the study reveals major "discontinuities" in DOC concentration and composition between porewater and pools within a peatland. This could have been done with a single spatially distributed sampling, but the authors complement this dataset by repeating the sampling over different seasons. The seasonal sampling corroborates the initial findings of "discontinuity" in the DOC concentration and composition between these two environments. Whatever hydroclimatic conditions, the DOC in the pools and surrounding peat porewater seems to be considerably different. Overall, I find the dataset presented here to be interesting and the methods and statistics are sound. However, I have some concerns over the interpretation of the findings and how they support the conclusions of the study. In addition, I have made some recommendations to improve the data visualizations and some elements of the text, mainly the discussion.

Causes of Discontinuity:

The peat reaches 4m deep in some locations (line 106) (often near the pools based on the map in Pimeau and Garneau 2021), but the porewater sampling considered only the top 2m (Line 125). I expect the reason for that is the assumption that hydraulic conductivity decreases exponentially with depth (stated in discussion 460-466). Therefore, the porewater in the bottom 2m of the peat profile is considered to move very slowly and contribute little to runoff generation or the water contained in pools.

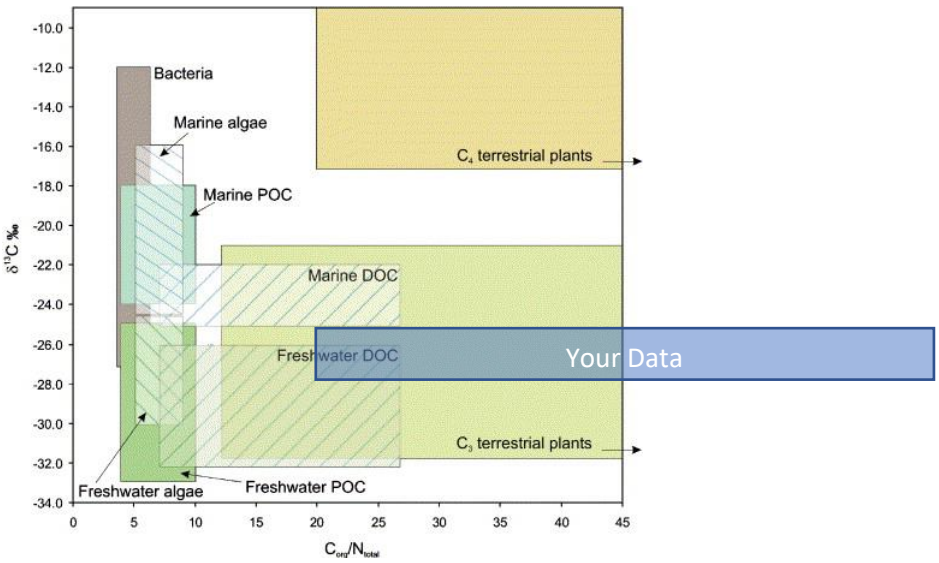
However, deep preferential flow areas exist in many peatlands (often below 2m deep) (e.g. two Swedish studies DOI: 10.1111/gcb.13815, DOI: 10.1002/hyp.10300 (one where I was involved, sorry for citing myself), UK peatlands (e.g. DOI:10.1016/S0341-8162(01)00189-8) and GLAP peatlands (DOI:10.1002/2016GB005397, DOI: 10.1002/hyp.9983). These studies have shown that deep peat horizons can contribute to a large fraction of the runoff generation, or at least be hydrologically active. The high hydrostatic pressure in deep peat preferential flow areas can make that water emerge rapidly to the surface in specific locations, for example in streams or pools. Could this also be the explanation here? The water and C found in pools could in fact be feed predominantly from the bottom instead of laterally? This could also explain why the water table is more stable in the pools than the peat porewater (Line 300, Fig SI2). Hence, the discontinuity in DOC concentration and composition observed here could in fact be due to that the sampling didn't capture the actual source of water and C (if it is located below 2m deep). The difference in specific conductivity between the pools and peat porewater, which here could act as an independent water tracer, indicates different water sources (Line 304-306).

Assuming the authors finds this to be a plausible explanation, I want to highlight that I still find the results of the study to be interesting and relevant by simply highlighting the major and persistent disconnect between surface porewater and pool water. This disconnect possibly arises as a result of the complex hydrology of peatlands. Maybe the paper would benefit from emphasizing this disconnect rather than to suggest a "common source" and find a reason for the apparent discontinuity (which are suggested to be a combined result of hydrological, chemical and biological process) (see my comment on the discussion). Maybe it's my background showing here, but I believe a missing water source could explain nearly all the observed patterns in this dataset.

The Common Source:

The section 5.1 of the discussion claims that the differences in DOC concentration and composition hide a common source. The author claims that common source to be C3 plant-derived, which leads me to wonder - what else could it have been in a boreal peatland? I have several issues with this aspect. 1. It seems obvious to me that the DOC would be predominantly plant-derived in a peatland and therefore doesn't constitute a hypothesis that needs testing nor a substantial finding, 2. The author hasn't clearly stated what other possible sources could be, I suppose these are "*C4 plants*", which generally are absent at this latitude or "*microbial-derived*" which are certainly overridden by the decomposing peat material. 3. The vocabulary often changes, sometimes this source is referred to as "terrestrial contribution" "vegetation origin" "plant-derived". I suggest that the other clarifies both the hypothesis tested here and the vocabulary.

This leads me to further concerns over the interpretation of the d13C-DOC values and the correlation between d13C-DOC and DOC_DON ratio in Figure 3. The d13C-DOC values reported here varies across a narrow range (-25 to 28‰) and show that DOC originated from C3 plant metabolism. Meanwhile the C:N ratio show that the DOC is strongly terrestrial as opposed to aquatic. This is not surprising. But I doubt that anything else can be said of these values. What is the interpretation of the correlation Fig 3? the discussion mentions this correlation briefly on line 421-423 and Line 434-436 (albeit a missing reference to the figure here). The authors state that this correlation reveals that DOC comes from plant leachates instead of microbial exudates, but I don't see how this is supported. The study cited here (Magill and Aber, 2000) has no mention of the stable C isotopes. Are you suggesting that there is a fractionation process taking place here, whereby DOC becomes lighter with increasing DOC:DON ratio due to microbial or photodegradation? Below is a typical biplot from a review paper on d13C-DOC and DOC:DON across ecosystem types that puts in context your data (https://doi.org/10.1016/j.earscirev.2005.10.003).



It seems that the correlation between d^{13}C-DOC and C:N ratio might be just coincidental. The mechanism to explain why these two variables should be correlated has not be stated. Further clarification of the interpretation of this correlation would be helpful.

The role of photodegradation in peatlands (Line 445 to 455)

I find interesting that the authors quantify the potential photodegradability of the DOC to understand the possible fate of the DOC in downstream environments. But I doubt that photodegradation within

this peatland catchment can possibly be an important process for the overall peatland C budget, given 1. the limited amount of light penetrating in peat and pools, and 2. The small areas covered by the pools. The DOC being transported with water will eventually leave the catchment boundary and maybe then photodegradation can then play a role. I find interesting that this aspect was quantified as a way to characterize DOC properties and act as another tracer of DOC sources, but the way it's presented here, in a context of a mass budget and as a possible mechanism for the disconnect in DOC between porewater and pool seems overstretched.

The influence of DOC adsorption. The peat porewater samples were collected through a PVC tube covered with a nylon sock. I would assume that the porewater DOC that is adsorbed to the peat to not sampled then. So can this mechanism really be important to explain the discontinuity between pool and porewater DOC?

Influence of Bioavailability (Line 441 to 444): Are local differences in DOC lability really important for a peatland given that other environmental factors limit the metabolism in peat porewater. It's again interesting to measure the lability of DOC as a tracer of DOC sources, but other possibly more important factors limit the degradation of DOC in peat soils. The author also states that the slow hydraulic conductivity increases residence time and therefore the potential transformation of DOC. This is true for most surface water environment (e.g. 10.1038/ngeo2720), but other possibly more important factor (e.g. electron acceptor availability) limit microbial metabolism in peat. I am not sure this is a relevant argument here, especially since hydraulic conductivity and water residence time were not quantified here as far as I am aware. DOC will be degraded once the environmental conditions allow it, and that is possibly outside of the peatland catchment boundary.

In general, I find that the text in the **discussion** could be improved. I have the feeling that the author is not fully satisfied with the main conclusion of the paper and tries to find more "positive" results to give value to the study. In my opinion, the fact that there is such an obvious mismatch between the DOC concentration and composition across seasons is not a failure, but an opportunity to reveal how dynamic peatland hydrology and DOC cycling can be. I would suggest that the author rework the discussion to emphases those differences throughout the discussion, instead of suggesting that there is a "hidden common source" (which is would always be plant-derived) and that those differences could be the result of hydrological, chemical, and biological processes. Why not embrace the idea that the source of DOC in surface porewater and pools are not the same (i.e. section 5.1), and discuss the possible reasons (section 5.2) and what the implications might be for role of pools in the DOC cycling of this peatland (i.e. section 5.3). What I am recommending here is not a major reworking of the discussion, but just a change in perspective, which could make the text more dynamic and with a clearer message. The title of the paper clearly highlights the main finding: " there is discontinuity in the DOC between peat porewater and pool across seasons" but the text seems to try to argument that this DOC might in fact be the same, it's just been biologically transformed/adsorbed to peat etc. I have made more specific suggestions on the subject in the "by line comment" section.

Data Visualization:

Figure 2 is a key figure presenting the data, but I find the box plot to be an ineffective choice of visualization in this case. There are too many plots and too many things being compared for this type of plot to work. A more effective visualization could be a parallel coordinate plot (e.g. https://datavizcatalogue.com/methods/parallel_coordinates.html). Each vertical axis would represent a different variable (e.g. DOC concentration, DOC:DON etc.), and each line moving laterally would be a different sample location. I would suggest to fade the peat porewater samples in the background and superimpose the pool water samples on top in a darker color to help compare these two

environments. You could even make it a three panel figure, one for each season. This would allow to see at a glance, which site/season bear most similarities and differences for all variables. If possible, maybe also indicate the meaning of optical properties on the axis, for example (higher SUVA values is more aromatic and lower is less aromatic etc.). This would facilitate the visual interpretation. This plot would also give the possibility to merge figure 5 and figure 2, in this case by adding another vertical axis for degradation rates.

If you choose to stick to the boxplot format please add letters on the x-axis to show statistically different groups. (e.g. function multcompLetters in R, library multcompView)

Can the symbols in the PCA (Figure 4) be the same at in Figure 6? Also note that all symbols in figure 6 are circles so there is an error here. The figure 4 could also be bigger for better readability.

Figure 1: Is it relevant to point the stream outlet?

By line comments:

Line 69 to 78: Those lines might fit better in the discussion if you choose to emphasize the differences in DOC sources between porewater and pools.

Line 383: Is it the "average" or "median" degradation rate that was statistically significantly different?

Line 410: Be more specific here. Is it the average or range in DOC, porewater or pool water? It can also be helpful for the reader that you write in bracket the number you are referring to, even if they are available in the table SI3.

Line 412-414: Do you mean here that the subarctic and boreal peatlands have on average 20 mgCL less DOC than temperate ones? Be more clear about what you are comparing here. Also, sentences starting with " A synthesis … " or " a study …" make the text more tedious. You can go straight to the point here and say for example. Porewater DOC concentration in peatlands exhibit a strong latitudinal trend, whereby boreal and subarctic peatlands contain …". Also, its not clear why this study is mentioned here and what argument you are trying to make. Is this just to state that your DOC concentration are "normal" or are you trying to extrapolate your findings to other latitudes

Line 420: same comment as for the previous paragraph: why is it relevant to put in context your number with latitudinal trends? Be more explicit about what you are trying to say here

Line 421: Instead of comparing with the name of the study, you could refer to the type of peatland that was studied in this paper Also, why are you making this comparison, again the argument is missing here: The DOC:DON ratios measured in peat porewaters at our study site were up to six times higher than in Austnes et al. (2010) " *suggesting that* …".

Line 452: This is a hypothesis here, no? The photodegradable fraction of DOC might have already been degraded prior to sampling, but the way it's written here makes it sound like you are certain that's the case.

Line 453: By consumption here you are referring to the biological pathway, not the photochemical one. Please clearify.

Line 462: can they “be explained by” or they can “arise as a result of”. This sounds like you are pleading a case for more “positive” result, while a more “negative” result in this case can be even more interesting.

Line 463: That doesn’t mean that water cannot be constantly filled from the bottom and just occasionally sourced from surface peat when the water table is high.

Line 410: The reference to table SI3 should be placed at the end of the sentence.

Line 410-415: Why mention this latitudinal effect? There seems to be an argument missing here. Do you mean that your data fit in with other peatlands at the same latitude? Please clarify.

Line 507-517: If the pools allow old DOC to make its way to the surface and therefore enter the peatland contemporary C cycle then they become very important for the stability of the old peat C stock. But based on the molecular weight indexes, the DOC seems younger in the pools than porewater

Line 520: My personal suggestion for future studies would have been to combine studies on DOC cycling with interdependent water tracer. It’s hard to trace back the cycling of DOC without knowing the water source.

Line 522: Exactly! I would even add, that the disconnect between the two environments persist no matter what the hydroclimatic conditions are.

Line 525: Or is the concentration just increasing because it gets drier? Maybe check if this difference persists once the DOC is volume-weighted based on water table position?

Line 534: the term “physicochemical parameters” is vague.

Line 535: What you say here is true, but I find it to be a disappointing end to a paper. The last sentence of the conclusion is very important and I am sure there is more a interesting take home message to be given here.

Table SI.3: DOC mean and SD?

Fig S1: If E2:E3 and Sr are both proxies of molecular weight (Line 189), why is it that they correlate so poorly?

Audrey Campeau