RYAN S.D. CALDER

February 19th, 2018

Ken Reimer, PhD, Chair
Independent Expert Advisory Committee
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Re: Reed Harris's comment on soil carbon submission from January 31st, 2018

Dear Dr. Reimer:

I am replying to your request for a response to comments made by Reed Harris on my submission to the Independent Expert Advisory Committee (IEAC) on the relationship between soil organic carbon (OC) and post-flooding methylmercury (MeHg) concentrations from January 31st, 2018.

- "Some of the published values Ryan Calder used to estimate carbon pools at ELA sites, shown in Figure 1 from his paper, may be incorrect and too low. There appears to be an error in the published values, which he could not have known. I initially looked into this matter because I needed information above and beyond the published information, to apply the RESMERC model to the FLUDEX sites at the Experimental Lakes Area, so I requested and analyzed raw data. The percent carbon values shown in Figure 1 also seemed very low for soils that presumably had an organic horizon. I could not match the values for carbon pools at the FLUDEX sites from Hall et al (2005) using the raw data. This was discussed with two FLUDEX researchers who published papers on the FLUDEX experiments. Britt Hall did not find (yet) the origin of the published values for carbon pools for the fungal/humic layer, expressed as kg C/ha, but did find estimates that were much higher, although still lower than estimates for Muskrat Falls. Unless the origin of the published values is found and verified, Britt Hall suggested using the higher, unpublished values in the current analysis. Updating the FLUDEX values could change the relationship between methylmercury and carbon in Figure 1. The change may or may not be significant, but the update should be done to determine this."

  Response

  I have explored the sensitivity of the relationship between post-flooding MeHg concentrations and soil OC content derived in Figure 1 in Calder et al. (2016) to the soil OC values reported by Hall et al. (2005). Large hypothetical adjustments to the Hall et al. soil OC values have a small influence on the linear regression coefficient derived by Calder et al. For instance, if the Hall carbon values are multiplied by a factor of two, the regression coefficient decreases by 5%. Figure 1 below illustrates how the regression coefficient from Figure 1 in Calder et al. (2016) responds to hypothetical adjustments applied to the soil OC values reported by Hall et al. (2005). Mr. Harris's comment above on the magnitude of unpublished values relative to Muskrat Falls suggests that the maximum potential adjustment factor for soil organic be considered would be 2.3.

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This analysis suggests that hypothetical adjustments applied to the soil OC content reported by Hall et al. (2005) have a minor influence on conclusions drawn from Figure 1 in Calder et al. (2016). This potential source of uncertainty is small in comparison to the uncertainties already expressed explicitly by the probabilistic modeling framework retained by Calder et al. (2016).

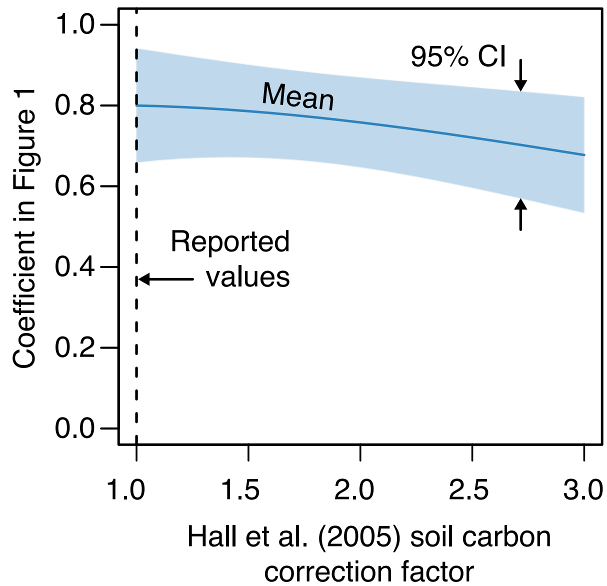

Figure 1: Effect of adjusting OC content values reported by Hall et al. (2005) for three reservoirs in the Experimental Lakes Area, Canada on regression coefficient reported in Figure 1, Calder et al. (2016). Correction factor multiplies soil OC reported for each of the three sites.

- "Calder et al included the mineral soil layer when estimating the carbon content for the ELA upland sites (FLUDEX experiment) shown in Figure 1. This would significantly lower the depth-averaged percent carbon if compared to just using the organic horizons, because mineral layers have very low carbon content. While it is debatable what depth should be used when estimating carbon and methylmercury concentrations in flooded soils, my expectation is that only the top few cm (e.g. 3-5 cm) are most influential for the MeHg flux to overlying waters. First, this is the zone in direct contact with overlying waters. Methylmercury concentrations in sediments are also often greatest in the top few cm, and methylation is commonly reported to occur where oxygen becomes depleted, favouring microbes that methylate mercury such as sulfate reducing bacteria. In flooded soils this transition to anoxic conditions likely occurs well within the top few cm. Also, methylmercury production in deeper sediments has limited connectivity with overlying surface sediments and fluxes to the water column because diffusion in sediments is slow. The depth selected has a big effect on estimates of carbon content and differences among sites. For example, what if one site has a 5 cm organic horizon while another has a 20 cm organic horizon? Would the methylmercury fluxes to overlying waters be similar or very different for these two sites? Organic material below the top few cm could still be important, affecting how long elevated methylmercury supply occurs to overlying waters, as decomposition consumes the original surface layer and underlying material is closer to the new surface. A related consideration is whether bank erosion and sedimentation rates in the new reservoir will cover organic matter."

Response

Figure 1 of Calder et al. (2016) aggregates all available soil data for all available sites as explained in my submission to the IEAC from January 31st, 2018. This includes the three reservoirs reported by Hall et al. (2005), where mineral soils were included. As also explained in this submission, the organic soil layer in that environment is thin and, in some places, nonexistent.

Plotting MeHg vs. OC for surface soils only would produce a graph with higher values for both MeHg and OC. The data presented in my submission from January 31st 2018 clearly supports a linear relationship between MeHg and OC over all measured values of OC. Therefore, I would not expect a substantially different relationship if data were selectively excluded in the way proposed above. I however agree that the uppermost layer of soils is most relevant for production and diffusion of MeHg into flooded reservoirs, but that the optimal averaging depth is unknown.

- "It is not clear what sample depths were involved for other sites in Figure 1. This would be useful to know. Did carbon estimates from other sites include mineral layers for example?"

  Response

  This information can be found in the papers cited.

  Because, for a given site aggregated in the analysis, the same linear relationship applies over all values of OC, MeHg and, implicitly, depth (which is collinear with both), selectively excluding certain values of depth (and therefore OC and MeHg) would not on average produce a different statistical relationship. Omitting data would however increase the confidence interval around the regression coefficient.

- "Calder's supplemental memo states that wetlands were excluded from the analysis because they may be sulfate limited. I am guessing however that a wetland site is included in Figure 1 (solid blue dot). Furthermore, if that site is the ELARP wetland, the carbon content is about 12% in the figure, which seems low for a wetland, and it is lower than the carbon content shown for a podzol soil. Does that make sense?"

  Response

  This is incorrect. The Rolfhus et al. (2015) data is from the FLUDEX sites nine years after the experiments reported by Hall et al. (2005). The reader is referred to the work cited.

I hope these answers are useful to you. Please do not hesitate to contact me for any clarification.

Sincerely,

Ryan Calder, ScD, MASc

References

Calder, R. S. D., A. T. Schartup, M. Li, A. P. Valberg, P. H. Balcom and E. M. Sunderland (2016). "Future Impacts of Hydroelectric Power Development on Methylmercury Exposures of Canadian Indigenous Communities." Environ Sci Technol **50**(23): 13115-22.

Hall, B. D., V. L. St. Louis, K. R. Rolfhus, R. A. Bodaly, K. G. Beaty, M. J. Paterson and K. A. P. Cherewyk (2005). "Impacts of reservoir creation on the biogeochemical cycling of methyl mercury and total mercury in boreal upland forests." Ecosystems **8**(3): 248-66.

Rolfhus, K. R., J. P. Hurley, R. A. Bodaly and G. Perrine (2015). "Production and retention of methylmercury in inundated boreal forest soils." Environ Sci Technol **49**(6): 3482-9.