Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2018-327-AC2, 2018

Biogeosciences
Discussions
Open Access

Interactive comment on "Variations in river input of iron impact sedimentary phosphorus burial in an oligotrophic Baltic Sea estuary" *by* Wytze K. Lenstra et al.

Wytze K. Lenstra et al.

w.k.lenstra@uu.nl

Received and published: 5 October 2018

Review of Lenstra et al. 2018 - Variations in river input of iron impact sedimentary phosphorus burial in an oligotrophic Baltic Sea estuary Decision I would be happy for this manuscript to be published after some minor corrections.

Manuscript Quality The paper contributes knowledge of phosphorus burial a research largely overlooked in favour of carbon and nitrogen. The research focus on the main drivers of P burial in the northern Baltic sea, though a regional study this work will be of interest to a wide audience and highly relevant to Biogeosciences. The authors report that in this area a significant portion of the P burial is associated with vivianite crystalli-

Printer-friendly version

Discussion paper

sation this coupled with they're model outputs highlight an important mechanism for P. Burial where increase in fresh riverine water and iron increase P burial.

The hydrological context of this research does need better clarification.

Visual Quality Both the figures and tables are of high quality and are ready for publication.

Technical Quality The methodologies they authors used were appropriate and applied correctly, I cannot comment on modelling. I would have liked to see the core chronologies in the main text not the Sup Mat but Table.1 does provide enough information.

Reply: We thank the reviewer for the positive remarks. Below, we provide a point-by-point reply to the comments and we will revise the manuscript accordingly. The comments of reviewer #2 partly overlap with those of reviewer #1. We have indicated when and where this is the case. Comment #1: Major Comments Clarify if the flow measurement were made for the Ore river as the title and abstract suggest that the authors are directly linking river input and P burial but this is not supported by the data.

Reply: Please also see our reply to comment #1 of reviewer #1. We agree with the reviewer that measurements of riverine Fe input would form a useful addition. Unfortunately, long term measurements of total Fe input are not available for the Öre River (or any other rivers in the region) and therefore cannot be included in this manuscript. However, by modelling key porewater and solid phase depth profiles in the Öre Estuary, we demonstrate that large temporal changes in Fe and organic matter input are necessary to fit our model to the measured data at this site (P. 8-9 section 3.4). Because the study area is such an oligotrophic coastal region, the large temporal changes in Fe and organic matter input to sediments located at a river mouth can only be explained by variations in river input.

Comment #2: The data from the Ore river does differ from the averaged flows from the 86 other river is there a reason for this. Is the Ore and its catchment an oddity or is it comparable to other estuaries in the area.

Reply: Please also see our reply to comment #3 of reviewer #1. Spatial and temporal patterns of rainfall over Sweden are expected to differ and result in differences in river discharge between the 86 rivers and the Öre River. Meltwater, for example, plays a more important role for rivers at high latitudes when compared to lower latitudes. As described on P.13 in lines 4-11, the 1996 dry period affected the entire Baltic Sea region. This was less so for 1976.

Comment #3: The authors have cores form 5 sites (NB1,6,7,8 and 10) but only model site NB8. Is there a reason for this and how comparable are the different sites. From Fig.5 it is clear that all the data falls within the same ranges but NB8 is the furthest from the river mouth and a clear statement on why the model was applied to only this site would be useful.

Reply: Please also see our reply to comment #7 of reviewer #1. In this study it was our aim to assess the burial of P in and below the SMTZ and the factors contributing to temporal variations in P burial, including the role of the rate of sedimentation. As we were not able to sample below the SMTZ at sites NB1, N6 and N10 (April) and the geochemistry of sites N7 and NB8 is comparable, we focused on site NB8. At site NB8 we subsequently performed three types of chemical extractions and experimental work to allow for visual observations of vivianite. We did not obtain these data for the other sites. The geochemistry at site NB8 is strikingly similar to that at another site with a high sedimentation rate in the Bothnian Sea (Egger et al., 2015a, b), as discussed in the manuscript (e.g. P2, lines 15-17).

We have changed the text in the model description section to clarify that we selected NB8 because it has a shallow SMTZ and a relatively high sedimentation rate (P.7 lines 3-4): “Site NB8 was characterized by a SMTZ close to the sediment-water interface and a relatively high sedimentation rate (Table 1).”

Comment #4: One important question that seems to have not been mentioned is the potential for the Fe-P to be bound to FeOx. I think an additional figure illustrating downcore profile of Total Fe, FeOC, Fe-P and possibly vivianite bound P and organics.

Reply: In the extraction methods that we used there is not a specific step, which only extracts vivianite. In the SEDEX vivianite is extracted together with P bound to Fe oxides (Dijkstra et al., 2014, Nembrini et al., 1983). In the Fe extraction vivianite is extracted in both the HCl-Acetate and CDB step (Dijkstra et al. 2014). Therefore a single figure containing measured data of P bound to vivianite and P bound to Fe oxides is not possible. However, with the model we can make the distinction between these phases. Therefore we added a figure to the supplements (Fig. S.7), which shows the change in Fe bound in vivianite and Fe oxides as well as P bound to vivianite and Fe oxides. We now describe the figure in the results (P.10, line 29): “At depth, P bound to vivianite becomes more important compared to P bound to Fe oxides (Fig. S.7).” The relative contribution of Fe-oxide bound P and vivianite is discussed in lines 9-11 on page 12: “Due to dissolution of Fe oxides and vivianite formation in the sediment the fraction of P bound to vivianite increases with depth (Fig. S.7).”

Comment #5: Again line 4 Pg 13 – the refer to the years of 1977 and 1997 as high flow years but both looking at the Ore flow rates and S.Fig8 I would say that they have larger flows. I would focus more of the low flow years proceeding as the major mechanism.

Reply: Please also see our reply to comment #2 of reviewer #1. We agree that the river flow in the years after each relatively dry period (1976 and 1996) was not exceptionally high. The mechanisms that we propose in this manuscript as a reason for the enhanced input of Fe depend on the relatively low river flow in the years 1976 and 1996 being followed by a higher, more average, flow when directly compared to the preceding dry period. For clarity we changed the text: P2. line 25 from “In ensuing wet periods” to “After dry periods” P.13 line 5 from “In the following wet years,” to “in the following years”. P14 line 14 from “in a wet period directly following a dry period on land in 1976 and 1996,” to “in a period following a dry year on land in 1976 and 1996.”

Comment #6: Along the same lines do you have any rainfall data for this period this could be useful in further contextualising the low flows. A quick look at the UEA North Atlantic Oscillation records https://crudata.uea.ac.uk/cru/data/nao/nao.dat) both 1976 and 1996 were in the negative phase meaning dry conditions for the higher latitudes. In particular 1996 was in a very strong negative phase (NAO index:-3.27) explaining the low flows. Work completed in Scottish fjords (restricted marine environments not too dissimilar to the research area) showed that during negative NAO phases material builds up in the catchment and when the NAO switches that store of material is quickly transported to the sea – This mechanism may explain the increases in FeOx after the dry/low flow periods.

Gillibrand, PA, Cage, AG & Austin, WEN 2005, 'A preliminary investigation of basin water response to climate forcing in a Scottish fjord: evaluating the influence of the NAO' Continental Shelf Research, vol. 25, pp. 571-587. DOI: 10.1016/j.csr.2004.10.011

Reply: We agree with the reviewer that the NOA could play an important role in regulating the amount of precipitation on land, the related changes in Fe chemistry and the subsequent transfer of Fe to estuaries. We have now added a reference to the work of Gillibrand et al. (2005) and state that periods of low rainfall may be related to a negative phase in the North Atlantic Oscillation. We could not find any mention of particulate matter in the cited study, however.

Revised text (P.13 line 5): "We suggest that these high inputs of Fe and organic matter are directly linked to variations in river discharge, that may be linked to negative phases in the North Atlantic Oscillation (Gillibrand et al. 2005)".

Comment #7: The authors do focus on the role of salinity as a key component of the P burial process but as the modelling only takes place at the most saline site is the importance of this overestimated. Clarification would be useful.

Reply: The salinity at all sites was comparable (∼5), therefore an overestimation is not expected. It would be interesting to also sample sites with fine-grained sediments and

Printer-friendly version

Discussion paper

a lower bottom water salinity. These types of sites were, however, not found in the Öre Estuary. To obtain insight in the role of salinity, we performed a sensitivity analysis (Fig. 9). Our results highlight that a lower salinity would increase the role of vivianite formation.

Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2018-327, 2018.

Printer-friendly version

Discussion paper