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Discussions

Interactive comment on "Efficient removal of phosphorus and nitrogen in sediments of the eutrophic Stockholm Archipelago, Baltic Sea" *by* Niels A. G. M. van Helmond et al.

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Efficient removal of phosphorus and nitrogen in sediments of the eutrophic Stockholm Archipelago, Baltic Sea

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The manuscript addresses the critical process of sediment P burial for the development of eutrophication. It also covers nitrogen turnover on which I am not an expert. My

review will therefore focus on the P.

The burial of P in accumulation bottom areas in four sites is presented with high-quality data, both regarding the accumulation rate of matter and the P content and P-forms in these layers. I find the manuscript well written in terms of language and easy accessible. I do, however get the impression that the main scope with the P investigation partly was something more than the burial as it is presented; a "sink-switch" process to e.g vivianite-formation, as evident from the many references included covering that possible process.

Main concerns

The outcome of the study regarding the P burial ends up rather basic by summing up total-P concentrations in deeper sediment layer with the sediment accumulation rate at the specific site. With all the supporting data presented, perhaps could new insights be developed?

I suggest a more in-depth analysis of the P burial both in a spatial (quantitative) scale, as well as in a qualitative (formation of refractory P that forms during diagenesis and resists it) perspective. I offer my reflections on the subject as a platform to develop the discussion:

Does the lack of concentration changes in most P forms with sediment depth (Fig. 6) actually reflect mainly inert P forms settling out on the sediment surface, resistant to sediment diagenesis? Even the "authigenic P" (Ca-P) seems thus to have been formed elsewhere than in the present sediment profile, since it already in the top sediment layers is present at a concentration it will remain throughout the sediment profile. The "sink-switch" process seems to be virtually absent (except perhaps for the Strömmen station).

Indeed, some share of the organic P settling out on the sediment surface is mineralized, as evident from the decline in org-P concentration in the top ca 5 cm. This is

well presented in Fig 9 where the ”background” concentration is indicated. Perhaps the ”top-layer” (indicated as red labelled “surface sediment sink”) actually represents the P active in turn-over, as suggested in Rydin 2011. All the P indicated as background concentration would then largely be inert P forms, not relevant for the eutrophication process. A key question would then be to what extent autochthonous organic P (e.g. plankton) contributes to the supply of organic sediment P resistant enough to get permanently buried. Is the only main sink-switch of importance in this region the transformation of dissolved P in the water column to organic P (plankton), to a larger or lesser extent permanently buried in the sediment?

Line 391: Only “near shore construction and dredging (line 391) is presented as alternative sources for the P accumulated than land-derived. Another explanation for the high burial rate could be that the sediment to a large extent consists of old sediment (old clays) that already have undergone sediment P diagenesis processes one or even several times during the Baltic Sea life span, exposed to resuspension due to land up-lift (ca 0,5 cm/yr), and a secondary (or a third) settling out on accumulation bottom areas (Karlsson et al 2019 and references therein). But also P from the catchment (e.g. Lake Mälaren) of course contributes to this pool of P.

A back of the envelope calculation regarding the Lake Mälaren impact on the P burial in the region might look something like this: The Stockholm county archipelago covers a water area of 3100 km2. Assuming that only 25% of this area represents accumulation bottom conditions; 780 km2, and an average burial rate of 3 g/m2 yr, it ends up to 2340 ton P/yr. This is a high flux compared to external inputs, and corresponds to as much as ca 15% of the total P input to the Baltic proper. Thus, a high share of the P found in accumulation bottom sediment seems to be recycled.

To summarize my thoughts: the archipelago sediment seems effective in permanently trapping already inert, particulate P. But less efficient in transforming the “surface sediment sink” (Fig 9) into P forms that will be permanently buried.

The Discussion can be expanded with comparisons to other studies regarding accumulation of matter and phosphorus in the region; see Karlsson et al 2019 for suggestions on references for a more developed Discussion. Both the “surface sediment sink” (Figure 9), and the sediment accumulation rate, in Baggensfjärden and Erstaviken, are close to those found in a recent study in the adjacent Björnöfjärden (Rydin & Kumblad, 2019).

Specific comments

Figure 10 is of limited value since it (only) shows that the P concentration at depth is rather constant, and the burial rate is largely dependent on sediment accumulation rate (at the investigated sites).

The references need a check. Are all the references present needed? Line 802: Rydin et al 2011 reference is missing.

Line 900: It would be useful to present sediment accumulation rates as g DW/m2 yr besides cm/yr to compensate for the compacting of the surface sediment.

References Karlsson, M., Bryhn, A., Håkanson, L., Hållén, J., Jonsson, P., Malmaeus M, Rydin E. 2019. On the role of sedimentological processes controlling phosphorus burial in the coastal zone of the Baltic Sea. Limnology and Oceanography 9999:1-4.

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