

BG-2022-143 RC1

General Comments

This well written and thorough manuscript describes the biogeochemical processes occurring in the Elbe river estuary and links these to anthropogenic influences. The modelled biogeochemical cycles are well considered and describe a large source of TA within the estuary. This TA source is described as being caused by the dissolution of CaCO₃ sediments which is assumed to be driven by the increased organic matter and N loading of the estuary. Biogeochemical processes are explored in detail, although much of this is hypothetical discussion.

One weakness of the study is that all biogeochemical processes are estimated from dissolved concentrations rather than from other field observations, for example benthic sediment incubations or water profiles. The estimation of biogeochemical processes within estuaries is complex due to the dynamic interactions occurring over tidal cycles (salt wedge and tidal movements influencing benthic sediment interactions), diel cycles (changes in benthic O₂ caused by respiration/photosynthesis), seasonal cycles influencing metabolism rates, and all influenced by different riverine flow rates. While I agree that the processes identified here are likely occurring within the estuary, the accuracy of the predictions (e.g. that 90% of TA is due to CaCO₃ dissolution) may have a high level of inaccuracy and may have high temporal variability. It is useful to use modelled results, however it is important to highlight the uncertainties and assumptions associated with them in all sections of the manuscript.

AC: Dear reviewer, thank you very much for your positive feedback and the helpful comments and suggestions to improve the manuscript. We have addressed your suggestions in order to improve the manuscript. You will find our answers below.

We used field-observations of dissolved inventories that include the net metabolic generated amount of the parameters, rather than rate measurements. We rely on the strength of integrative capacities of our tracers (TA & DIC), which facilitate reliable estimations of metabolic processes. Such estimations should be seen as a powerful approach complementary to direct rate or process assessments.

We are aware that this natural system is variable and naturally influenced. The assessment of variability is out of scope of this work, but the further investigation of natural variability should be addressed in future research. We added a statement to uncertainties due to natural variability in the text.

Other Comments

L17 – wording - ‘resulting in maximum’

AC: We changed the wording in this sentences “resulting in a maximum TA generation of 90% due to...”.

L60 – I suggest separating the two research questions for clarity. I also note that the 2nd research question doesn’t receive much attention in the abstract or conclusion.

AC: We included sentences with highlighting the result of the second research question in the abstract and conclusion, and highlighted the two research questions in the introduction.

L65 – Provide more detail on ‘surface water samples’.

AC: We added more details for the surface water samples and how they were collected.

L139 – What is the source of wind speed measurement DWD? If wind speed was not measured in situ then where was the data source and at what resolution was the data collected as wind speed can greatly influence flux estimates and this uncertainty should be clarified.

AC: The wind speed was measured in situ by the federal authority Deutscher Wetterdienst (DWD). We clarified this in the text.

L157 – Provide details of box volume measurements and fill time estimates. Errors associated with both volume and fill time should be incorporated into the mass balance calculations. E.g. errors in the generic river width, depth etc. in Table 1.

AC: For the box separation, we defined boxes that of course does not consider the real river volume. However, the uncertainty of the box volume is indirect already included in the error estimation while estimating the error of fill time, as the product of box volume and discharge.

L176 – Outer boundary conditions measured two months later. Is this an issue? Please justify.

AC: We do not consider the use of the outer boundary conditions as an issue, because they represent average summer values for this region in the North Sea. The data originated from the nearest observation to point and time, and the difference in observational time appears to be in range of the flushing time of the southern North Sea.

L190 – The sentence is vague and poorly structured. Clarify the term ‘imported’ and clarify the link between PIC and CaCO₃ dissolution.

AC: Thank you for this comment. We restructured the sentences and clarified the term “imported” and the link between PIC and CaCO₃ in the text.

L308 – This section contains the most clear findings of the paper but seems hidden within the manuscript.

AC: Thank you for highlighting this. We restructured the section and removed the text interruptions by Table 2 and Figure 5, while putting the text together to highlight its importance more.

Table 3. Errors of species in the first half of the table seem optimistically low. Are all cumulative errors considered? Errors of samples, box volumes, flow rates, fluxes...etc.

AC: Yes, we applied a standard error propagation, thus accumulated all errors. The absolute errors are listed in Table 3.

L437 – replace ‘vanishing’ with a more appropriate term.

AC: We changed vanishing into diminishing.

L442-L447 – This speculation reads as discussion not conclusions

AC: We agree and replaced this part into the discussion section 3.3.

END OF COMMENTS