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Interactive comment on "Establishing a sediment budget in the newly created "Kleine Noordwaard" wetland area in the Rhine-Meuse delta" *by* Eveline Christien van der Deijl et al.

Eveline Christien van der Deijl et al.

e.c.vanderdeijl@uu.nl

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We thank the reviewers for taking the time to read and review our manuscript. We address each specific comment below:

Reviewer comments are bold
Author comments are in plain text
The changes in manuscript can be found in the manuscript with track changes

1 Anonymous Referee #1

Remarks p2 line 11: sedimentation rates: this is not the same as accumulation rate or aggradation. The latter is the net elevation change (= sedimentation minus compaction or subsidence). These terms are mixed in the paper. E.g. in table 1, it is not clear if aggradation or sedimentation is shown. The results of this paper show aggradation data: change in elevation based on bathymetric surveys in the channels, both also sedimentation data based on cores on the flats. This difference is not properly discussed. This sedimentation rate might be higher than the elevation change due to subsidence. Table 1 show in the header "Turbidity", while often suspended matter concentrations are shown.

We agree with the reviewer that the sedimentation rates presented may also be affected by subsidence and compaction. The elevation change based on the bathymetric surveys includes both subsidence and compaction. According to Kooij et al., 1998 the rate of subsidence (deep vertical regional land movement) in the Biesbosch area is low and amounts to -0.25-0 mm year-1, including compaction (-0.1-0 mm year-1mm year-1), isostasy (-0.1 mm year-1), and tectonics (-0.03 mm year-1). However, shallow surface compaction is likely considerable, but this has affected both the change in elevation based on the bathymetric surveys and the sedimentation data based on the cores on the flats. Therefore, we have decided to use the term net sedimentation for the rate of change in height based on the bathymetric data. This is explained in line 32 on p. 2. We use the terms sediment deposition or sedimentation for the average amount of sediment deposited annually derived from the cores on the flats.

Furthermore we have made the following changes in table 1:

- We have adapted the title of the second column from Accumulation [mm year-1] to net sedimentation [mm year-1] .

- We have changed the title of the third column from Accumulation to Deposition
- We have changed the title of the fourth column from Turbidity to SSC / Turbidity
- We have added a new column in between the former second and third columns. This column has the title Deposition [mm year-1]. When a source only gives the deposition in volume, the concomitant change in height, calculated using a sediment density of 1150 kg m-3, is shown in italics
- The caption of the table has been adapted to "Net sedimentation and deposition in various types of delta compartments. When a source only gives the deposition in volume, the concomitant change in height, calculated using a sediment density of 1150 kg m-3, is shown in italics"
- we have combined the studies of van Proosdij et al. 2006 and 2006a in Allen Creeck in one row.
- we have added the deposition rates for the Gleason and Walkerton marshes in the study of Darke and Megonigal 2003, for which only the accumulation rates were given in the first version of the manuscript
- we have added the deposition rates for the study of Bleuten et a. 2009

p2 line 14: the authors describe that sedimentation is controlled by frequency and duration of inundation, SPM concentration in the feeding channel. However, none of these data are shown for the study site! The latter would be very interesting to show, especially because table 1 shows this for other sites.

We have addressed this comment by an expansion of the description of the study site

in section 2.1. The exact changes in this section will be illustrated in our reply to the next comment

p3: description of the study site is not accurate enough. It is described as a tidal wetland. I interpret this as a wetland where water flows in and out, twice a day, based on the tidal cycle. The site has however an inlet upstream and an outlet downstream. Is there no change in current direction, causing inflow during flood at the downstream opening? In a tidal wetland, I would expect channels, bare flats and tidal marshes. Are there no marshes? The terrestrial zone is mowed to reduce hydraulic roughness: this indicated the area can be flooded. No information on this flooding (frequency, height, duration) is given..

In section 2.1, we have added a short description of the water levels, discharge, and suspended sediment concentration in the channels of the study area. Furthermore, based on the digital elevation model and water level measurements by Rijkswaterstaat (available for the entire period since opening of the study area), we changed the subdivision of the study area from channels, tidal flats, and terrestrial zone to subtidal area (surface elevation <0.125 mNAP, always submerged) , flats (0.125 mNAP - mean sea level), low marshes (mean sea level - mean high water), high marshes (mean high water - extreme high water), and a terrestrial zone (> extreme high water). We have also added information on the flooding frequencies of these different areas.

To clarify both the morphology of the study area and the division of the study area in subtidal, flats, marshes and a terrestrial zone, we have added a new figure (Fig2), which includes a cross section of the study area. The location of this cross section is also indicated in Fig1.

We have also added a more detailed description of the discharge regime and suspended sediment concentrations of the River Rhine. Unfortunately, no measurements are available for the River Nieuwe Merwede, which is the feeding channel of the study area. The exact inflow of water and sediment from the Rhine into the Nieuwe Merwede is unknown, since it varies due to the tide, the river discharge of the River Rhine, and the artificially controlled discharge through the gates of the downstream located Haringvliet barrier into the North Sea.

p4 line 28: there seems to be a big heterogeneity in the thickness of the deposited sediments. Using an average is probably very inaccurate to calculate the total sediment budget. Why not using a model, using elevation. The authors describe that sedimentation is significantly correlated with elevation.

We thank the reviewer for this suggestion. We now estimate the sediment budget using a model taking into account the surface elevation. For this, we divided the study area into navigable channels, subtidal area and intertidal area (flats, low and high marshes) and a terrestrial zone (not flooded during the study period). The sediment budget for the navigable channels was calculated from the bathymetric maps. For the subtidal area, the sediment budget was calculated using the average sedimentation in this area. The sediment budget for the intertidal area was calculated using a negative exponential relation between sediment deposition and elevation.

The exact changes in the description of the methods and results, can be found in the manuscript with track changes

p5: Terrestrial zone: only erosion is described here. But from the introduction, I derive that this part floods occasionally? Given the large surface of this part

(>50% of the total area), even a very small sedimentation during winter can have a significant effect on the total budget.

In the new model-based estimation of the sediment budget (see reply to previous comment), we now include the entire intertidal area, which is flooded occasionally. The new net sedimentation rates, and trapping efficiency are indeed higher than the estimates in the previous version of the manuscript.

The exact changes in the description of the methods and results, can be found in the manuscript with track changes

p5 line 17. No information on how the incoming load was calculated, is given. This is however important information. For the River Rhine some info is given: 10 minute intervals for discharge, daily SSC concentrations, between 2008 and 2015. Is this done with the same accuracy for the inflow in the area? Is there no inflow at the downstream opening during flood (see previous remarks)? Measurements of SSC at inflow and outflow would be a good way to calculate a trapping efficiency. The paper often refers to the total load of the River Rhine at the German border. How relevant is this? It is so far away from the site, after many branches and tributary rivers. I am more interested in knowing the total load of the Nieuwe Merwede that feeds the site with water and sediments: SSC and discharge in this river and SSC and discharge entering the study site. Unfortunately this information is not given.

We have added a more detailed description of the discharge regime and suspended sediment concentrations of the River Rhine in the description of the study area. Unfortunately, there is no measurement station in the Nieuwe Merwede, which is the feeding channel of the study area. The exact division of water and sediment from the River

Rhine towards the River Nieuwe Merwede is unknown, since it varies due to the tide, the river discharge of the River Rhine, and the artificially controlled discharge through the gates of the downstream located Haringvliet barrier into the North Sea. However, we measured water levels, flow velocities and suspended sediment concentrations at a 10 minute interval at the inflow and outflow of the study area between July 2014 and March 2015 (see van der Deijl et al., 2017). These measurements were used to estimate the fraction of sediment (5.8%) the study area has received from the total load of the River Rhine during this period. To calculate the total amount of sediment the study area has received since the opening of the study area, the fraction of 5.8% percent has been multiplied with the total load of the River Rhine, for which data is available for the entire period since the opening of the study area.

We have clarified the method of calculation of the sediment trapping efficiency in both the methods (Section 2.2.4) and the results (Section 3.5): the trapping efficiency was calculated based on the total sediment trapped in the area relative to the total amount of sediment the study area has received since the opening of the study area

P8 line 7: how is this 46% calculated?

We have clarified the method of calculation of the sediment trapping efficiency in both the methods (Section 2.2.4) and the results (Section 3.5): the trapping efficiency was calculated based on the total sediment trapped in the area relative to the total amount of sediment the study area has received since the opening of the study area

P10 line 22: is there seasonality in the sedimentation? What is the seasonality in discharge, in SSC, in tidal amplitude? How much do peak events contribute to

the budget? The peak in 2011, was it only a peak in discharge or did this event also had higher SSC?

In section 2.1 we have added more detailed description of the discharge regime and suspended sediment concentrations of the River Rhine. We also describe that the tide is mixed semidiurnal with a tidal range of 0.2 to 0.4 m. In addition, in section 3.2, we added a sentence that describes the response of the SSC concentration during the 2011 discharge event.

figure-1.png

Fig. 1. The study area Kleine Noordwaard, which is located within the Biesbosch Freshwater Tidal Wetland, in the lower Rhine and Meuse delta in the southwest of the Netherlands (a and b). Elevation is shown in meters, with respect to the Dutch Ordnance Datum (NAP) for the period before (c) and after depoldering (d).

figure-2.png

Fig. 2. Elevation of Transect A (see Figure 1) with respect to the Dutch Ordnance Datum (m NAP) with subdivision of the area into subtidal areas, flats, low and high marshes, and terrestrial zone relative to mean low water (MLW), mean sea level (MSL), mean high water (MHW), the maximum observed water level (EHW) and the water level for a peak discharge or storm with return period of 1 year, which were used to divide the study area in.