The Rhine Delta – A record of fluvial sediment trapping over various time scales

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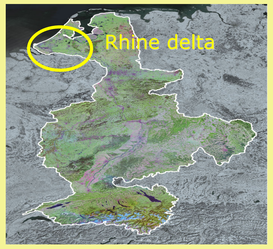
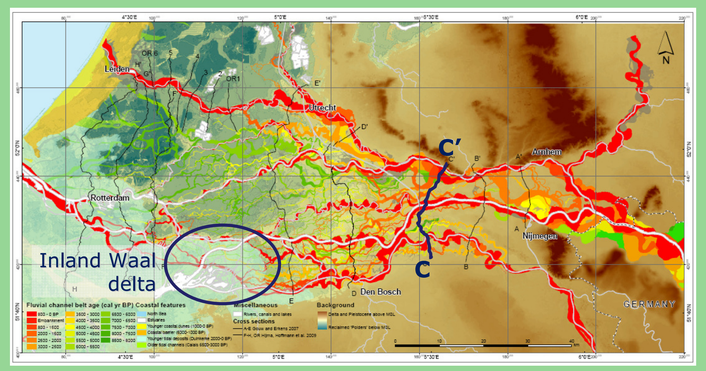
1. The delta as sediment trap

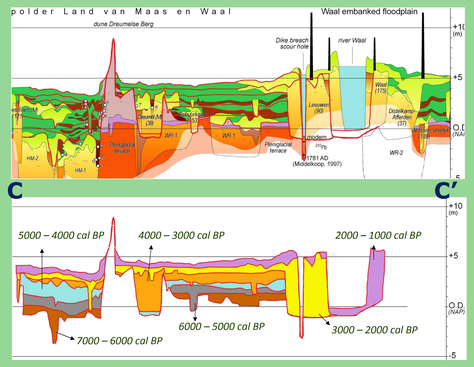
The Rhine delta forms the last trap for fine sediments from the Rhine basin before the river reaches the estuary.

In addition to sea level rise, human impacts in the upper basin as well as channel modifications in the delta have greatly affected the amounts of sediment trapped in the delta.

We quantified the amounts of fine overbank sediment trapped in different compartments of the delta over different time slices since 6000 BP.





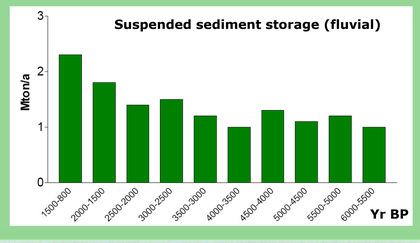


2. Natural delta: millennial time scale

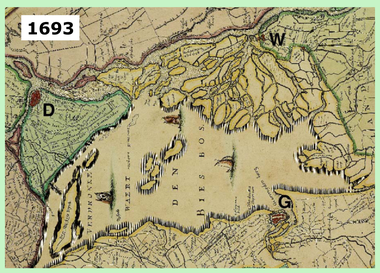
The Holocene Rhine delta contains a well preserved geological record of sediment deposition.

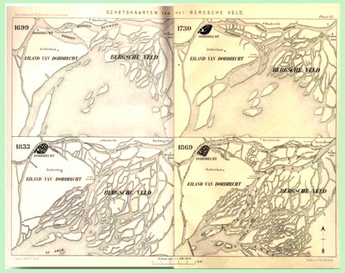
Method: Using our coring database we determined the amounts of sediment trapped over the past millennia using 8 detailed cross sections. Age control was based on >200 ^{14}C-datings.

Results: Sediment accumulation increased after 2000 BP.



3. Biesbosch: inland Waal delta





In an inland lake formed by the 1421 AD storm surge the Waal river built a delta.

Method: Using coring data and historic maps we reconstructed the delta growth from 1421 until its embankment in 1850.

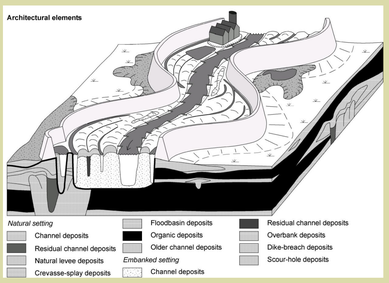
Results: The inland delta trapped about 200 Mton sand and 220 Mton mud

4. Embanked rivers: century time scale

After embankment (1200 and 1350 AD), sediment deposition was limited to narrow zones along the main channels.

Method: Using coring data we calculated the amount of overbank deposits. OSL dating and historic river maps were used to reconstruct lateral accretion and post-depositional erosion of floodplains.

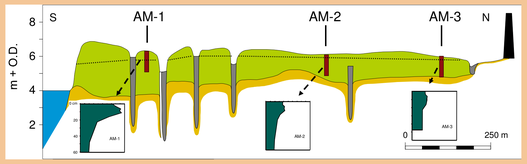
Results: After embankment, the floodplains have trapped 640 Mton overbank fines. About 70-80% of the floodplain deposits were re-eroded by lateral channel migration.

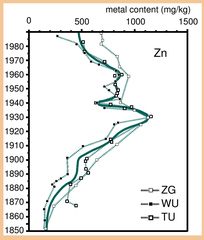


5. Normalized rivers: decennial time scale

After 1850 the channels were normalized by groynes, preventing lateral bank erosion.

Method: Post-1850 sediments were traced by enhanced heavy metal concentrations. The pollution history was reconstructed from floodplain lake sediments.





Results: The total sediment deposition after 1850 AD amounts to 173 Mton (10^9 kg).

Due to the channel fixation, re-mobilisation of older sediments has not occurred.

6. Embanked floodplains: Present-day sedimentation

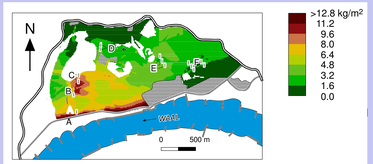
The present total embanked floodplain area is 168 km^2.

Method: We measured contemporary overbank sedimentation after several flood events using sediment traps.

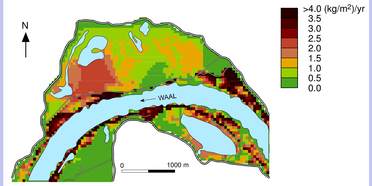
Using 2D models for overbank flow and sedimentation, we calculated average annual sedimentation.

Results: During the high-magnitude 1993 flood, total deposition along the Waal (main branch) was 0.24 Mton.

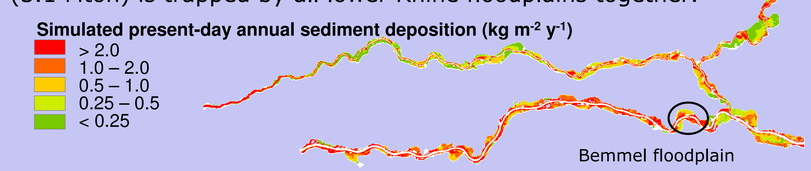
To date, about 39% of the annual suspended sediment load (3.1 Mton) is trapped by all lower Rhine floodplains together.



Bemmel floodplain, measured deposition



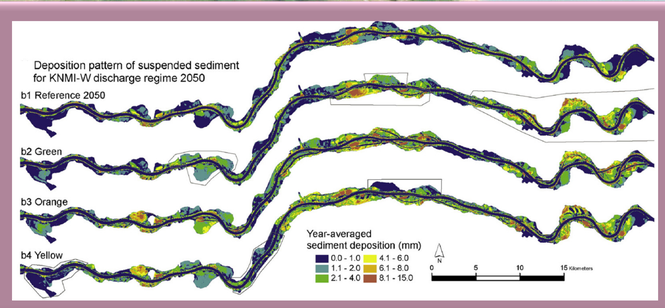
Simulated annual floodplain deposition



7. Future deposition

Using the 2D models we determined annual sediment deposition for future scenarios of climate and landscaping measures in the flood plains (lowering floodplain surface, removal of minor embankments, digging side channels).

Results: Climate change enhances deposition by + 60%; landscaping measures increase trapping efficiency: deposition doubles



8. Conclusions

Deforestation in the river basin increased deposition in the delta after 2000 BP. The bulk of these deposits have been well preserved.

Embankment of the river channels enhanced deposition, but preservation of deposits was low.

Channel fixation resulted in aggraded floodplains, which reduced the trapping efficiency, but preserved sediment.

Landscaping measures will rehabilitate floodplain deposition.