Morphodynamics of sand nourishments (sand engines) in eroding sections of the Rhine-Meuse Delta

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1. Introduction

To fight erosion processes and provide safety against dike failure, we carried out a pilot in which we nourished 50,000 m^3 of sand in 20 m deep scour holes in the Rhine Meuse delta. The research questions to be answered are how much these nourishments reduce the erosion, and how they can be used to stabilize the scour holes. We monitored and analysed the morphodynamics of the scour holes and surrounding riverbed. The aim of these pilots is to develop a strategy for sustainable sediment management, where these nourishments serve as a 'sand engine' to replenish the undersupplied sediment loads in these rivers.

The main river branches in the Rhine-Meuse Delta are incising under influence of redistributed tidal flows after closure of the Haringvliet estuary. The gradual incision into the heterogeneous subsoil causes development of deep scour holes that threaten the stability of the dikes (Huismans et al, 2021). Meanwhile these branches are important navigation routes, where frequent dredging is required to maintain draught requirements in aggrading sections. In the past, the dredged sediments were dumped in confined disposal areas or to the North Sea, and partially sold for construction purposes. Beneficial use of these (clean) sediments for fighting erosion and nature development is part of anticipated sustainable sediment management.

Figure 1. Nourishment operation, unloading above a deep scour hole in the 'Oude Maas' River, June 2022

2. Description of the pilots

The nourishments were executed in the first months of 2022 in two deep scour holes in the Oude Maas River (Figure 1). This sand was dredged in a river section about 20 km upstream. From each load of the trailing hopper suction dredger a sediment sample was taken, and its grain-size distribution analysed. Furthermore, monthly high resolution multi-beam measurements were made for a river section covering the scour holes as well as the downstream section. The maximum thickness of the nourished layer in the deep holes is about 5 m. Earlier, in 2018, similar nourishments (but much larger volume) were executed and analysed in a section about 10 km downstream. Both these projects are located just downstream of confluences, with complex flow patterns during both ebb- and floodtides.

2.2 Observations and analysis

From the pilots, as well as our previous studies on scour hole development in laboratory, and with 3D (OpenFoam) modelling, we learned that the nourished sand is resuspended, and flushed from the scour holes by complex 3D vortices and secondary flows. The net tidal currents cause this outflowing sand to develop trailing tracks that propagate slowly downstream (seaward) on the deeper parts of the riverbed and counteract the overall erosion. The propagation speed is in the order of one to a few hundred meters per year.

3. Conclusions

The nourished sediments successfully act as sand engines to the Oude Maas River. The complexity of flows in the scour hole (also affected by the nearby confluence), and unknown geotechnical properties make an exact evaluation on the stabilisation of the scour holes difficult. Erosion rate of nourished material and morphological development of the scour hole are therefore found difficult to simulate with numerical models. More successful is the modelling of sediment that reaches the riverbed, but the development of bed forms (dunes in tidal flows) also limit a very detailed prognosis.

Acknowledgments

This study is part of the Technical Knowledge and Innovation project "Proeftuin Sediment Rijnmond" led by Deltares. The pilots are carried out as part of the maintenance dredging contract of Rijkswaterstaat, executed by De Vries & van de Wiel, DEME Group.

References

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