The significance of biological activity for morphology and sand-mud distribution in the bed

The application of an extended sand-mud model to the Paulinapolder intertidal flat

M.Sc. Thesis

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Preface

This M.Sc. thesis forms the final project of my study Civil Engineering and Management at the University of Twente, the Netherlands. The subject of the project is biogeomorphology and the aim is to explore the significance of biological activity for morphology and the vertical sand-mud distribution in the sediment bed. The project is carried out at WL | Delft Hydraulics.

The project is financed from the research theme 'doelfinanciering Westerschelde' of WL | Delft Hydraulics. I am very thankful for this financial contribution. I would like to thank some people that supported me during this project. I thank Suzanne Hulscher (University of Twente) for bringing up the subject and for the comments that were always very directive and helpful to oversee the 'higher' objectives of the study. Further I would like to thank Michiel Knaapen (University of Twente) for more 'technical' supervision as daily supervisor. The comments were always useful.

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Further, I want to thank Linda Kusters (student Civil Engineering, TUDelft, graduated at WL), whom supplied me with a lot of data. Harriette Holzhauer (University of Twente) has provided me with a lot of knowledge and some crucial information and data.

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Summary

Biogeomorphology is the study of the interaction between (geo)morphological factors and biota. As a first step to understand the biogeomorphological interaction, the influence of biological activity on morphology and vertical sand-mud distribution in the sediment bed is analyzed. As the biogeomorphological interaction is complex, we focus on only part of these interactions (f.e. no feedback of morphology on biology).

Previous experiments have shown that biota affect the critical bed shear stress and erosion rate by several orders of magnitude. In the bed, benthos (little organisms that move through the bed) enhance sediment transport by decreasing the critical bed shear stress for erosion and increasing the erosion rate (*biodestabilization*). With high algae biomasses, algae-mats on the bed surface prevent the bed from erosion (*biostabilization*).

With a new *sand-mud-bio* model is shown that biological activity has a significant effect on morphology and the vertical sand-mud distribution in the sediment bed. To include biological activity in the model, a parameterization of the influence of biological activity on sediment strength parameters critical bed shear stress, erosion rate and vertical biological mixing coefficient, is implemented in a process-based sand-mud model. The model is applied to a part of the Paulinapolder, an intertidal flat in the Western Scheldt. It is a muddy area and biological activity is high during the year. Realistic flow and morphological conditions are set-up for the study area.

If biological activity is included in the morphological modelling it is shown that the system becomes muddy if it is stabilized and sandy if it is destabilized. This cannot be explained by means of physical processes only. The effects on bathymetry are significant as extra erosion of 10 cm and extra sedimentation of 2 cm occurs over half a year (compared to the reference situation). The destabilizing process seems to be dominant, however, no equilibrium mud contents are reached if the system is maximally stabilized.

A patchy distribution of biological activity results in even more effect on the erosion/sedimentation pattern. Significant bed level differences exist between destabilized and stabilized patches. It seems that sediment is transported in more extent to areas with lower bed shear stress than that sediment is redistributed between destabilized and stabilized patches. The mud contents in the bed generally follow temporal variations in biological activity.

The largest influence of biological activity is observed in areas with relatively low bed shear stress. Near the salt marsh, the system is in the cohesive regime initially. Biological activity triggers the switch to the non-cohesive regime, where the critical bed shear stress is lower and the erosion rate higher. The switch between the non-cohesive and cohesive regime is very important in the model. Vertical (biological) mixing in the sediment bed has an important influence on this switch as it influence the mud content in the top layer of the sediment bed. The model is less sensitive for variations in erosion rate.

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Appendices