Riverbank erosion induced by gravel bar accretion

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Riverbank erosion is known to be strongly fluvially controlled and determination of shear stresses at the bank surface and at the bank toe is a crucial point in bank erosion modeling. In many modeling attempts hydraulics are simulated separately in a hydrodynamic-numerical model and the simulated shear stresses are further applied onto the bank surface in a bank erosion model. Hydrodynamics are usually simulated at a constant geometry. However, in some cases bed geometry may vary strongly during the event, changing the conditions for hydrodynamics along the bank. This research seeks to investigate the effect of gravel bar accretion during high discharges on final bank retreat.

At a restored section of the Drava River bed widenings have been implemented to counter bed degradation. There, in an initiated side-arm, self-dynamic widening strongly affects bed development and long-term connectivity to the main channel. Understanding the riverbank erosion processes there would help to improve planning of future restoration measures.

At one riverbank section in the side-arm large bank retreat was measured repeatedly after several flow events. This section is situated between two groins with a distance of 60 m, which act as lateral boundaries to the self-widening channel. In front of this bank section a gravel bar developed. During low flow condition most discharge of the side-arm flows beside the gravel bar along the bank, but shear stresses are too low for triggering bank erosion. For higher discharges results from a two-dimensional hydrodynamic-numerical model suggested shear stresses there to be generally low during the entire events. At some discharges the modeled flow velocities even showed to be recirculating along the bank. These results didn't explain the observed bank retreat. Based on the modeled shear stresses, bank erosion models would have greatly underestimated the bank retreat induced by the investigated events.

Repeated surveys after events applying terrestrial photogrammetry, continuous observation of the bank section with a time-lapse camera and continuous measurement of soil hydrological variables showed that around the flow peaks steeper banks collapsed, when matric suction and hence soil shear strength decreased below critical values. But much larger bank erosion with continuous transport of failed blocks from the bank toe was observed to occur during the falling limbs of the hydrographs, when discharge went back to mean flow condition. The flow velocities along the bank then were much larger than at the same discharges during the rising limbs of the hydrographs. Surveys of the riverbed demonstrated a temporary decreased cross section for the flow along the bank because of aggradation and resulting gravel bar accretion during the event. The decreased cross section led to the high flow velocities and shear stresses observed at the end of the events. After every bar accretion, the cross section was re-established by bed degradation along the bank and by massive bank erosion.

Monitoring results of the gravel bar accretion and bank retreat are presented. Shear stresses modeled at a constant geometry are compared to the shear stresses modeled when bar accretion was considered. The results highlight the importance of non-equilibrium sediment transport processes during flood events for bank erosion and the need for its consideration in bank erosion modeling. Demonstrated here at a riverbank between groins, bar accretion may play a general role at gravel-bed rivers for bank erosion, particularly near lateral constraints.