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Flow and sediment properties of the river Rhine during floods: a reconstruction of historical changes due to human impact

R.M. Frings, B.M. Berbee, G. Erkens and M.G. Kleinhans
Department of Physical Geography, Utrecht University, The Netherlands (R.Frings@geo.uu.nl)

Human impact on lowland rivers has strongly increased during the past centuries. As a result, both the flow characteristics and bed sediment characteristics of the rivers changed, affecting channel stability, flood risk, navigability and ecological potential.

In the present case-study, we analyse the effect of human activities on the flow characteristics and bed sediment characteristics during floods. We focus on the sand-bed part of the river Rhine (Waal branch, the Netherlands). The objectives were: (a) to reconstruct the historical change in bed shear stress during the past 900 years, (b) to reconstruct the coeval change in bed grain size, (c) to identify the main causes of these changes. Various data sources were used, such as borehole descriptions, historical river maps and results from modern hydraulic measurements.

It was found that the bed shear stress in the river Waal strongly increased during the past 900 years. In the same period, the gravel content of the sandy river bed increased, causing a coarsening of the river bed. The coarsening was more or less homogeneous over the entire river length, leaving the downstream fining rate unaltered over time. In the period before 1870 AD, the shear-stress increase and bed coarsening were mainly due to the embankment of the river. In the period after 1870 AD, the shear-stress increase and bed coarsening were mainly due to the narrowing of the river and the dredging works. The increasing navigation in the 20th century caused transport of fine bank sediments from the groyne fields towards the river bed, locally resulting in a fining of the river bed.

It is expected that the present flow characteristics and bed sediment characteristics of the Waal are largely adapted to the human activities. The phenomenon of modern river sediments being coarser than deposits formed under natural conditions has also been observed in other rivers. This, for instance, implies that calculations of the historical sediment dynamics of rivers (often done in river restoration projects) should always be based on historical grain size data.