Sediment budget of the Rhine River for fractions clay/silt sand & gravel

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Knowledge about sediment transport in rivers is needed by engineers, geomorphologists, ecologists and river managers for a wide range of purposes, such as channel design, maintenance, sediment management etc. The Rhine River is one of the most important waterways in Europe. A sediment budget analysis is one basis for maintenance and optimization of the waterway. The Rhine drainage basin covers 197,000 km², is heavily populated with 58 million inhabitants and is connecting the port of Rotterdam to the industrial areas in the hinterland.

In order to improve navigation conditions, 19th century river engineers increased the water depth, energy slope and bed-shear stress and transport capacity. In the 20th century, the sediment supply from the hinterland was strongly diminished by the building of dams in the river and its tributaries. The Rhine is still reacting to these impacts by entraining sediments from the river bed leading to net erosion.

The river itself has been deepened and narrowed, with groynes and bank revetments preventing bank erosion. In order to allow year-round navigability continuous dredging operations are carried out. Dredged sediments are re-allocated to the river downstream. Furthermore, large amounts of sediments are artificially supplied to the river to stop bed degradation and to fill scour holes.

The Federal Waterways and Shipping Administration carries out systematic measurements of the sediment transport in the Rhine since 1965 using the BfG bedload sampler and suspended sediment samples.

This dataset with thousands of bed-load and suspended-load measurements was used to quantify the fluxes of gravel, sand, silt and clay through the northern Upper Rhine Graben and the Rhenish Massif. Sediment transport rates were found to change in the downstream direction: silt and clay loads increase due to tributary supply; sand loads increase due to erosion of sand from the bed; and gravel loads decrease due to a reduced sediment mobility caused by the base-level control exerted by the uplifting Rhenish Massif. Sand being eroded from the bed is primarily washed away in suspension, indicating a rapid supply of sand to the Rhine delta.

Bed degradation and artificial sediment feeding represent the major sources of sand and gravel to the Rhine River; only small amounts of sediment are supplied naturally from upstream or by tributaries. Sediment sinks include dredging, abrasion and the sediment output to the downstream area. Sand was found to be the main morphological agent.

The results of this sediment budget may also serve as calibration dataset for numerical models.