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Quantification of fine sediment retention in the Rhine delta using a two-dimensional floodplain sedimentation model

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The embanked floodplains (washlands) along the lower River Rhine distributaries in the Netherlands act as a prominent sink for fine sediments and associated pollutants. Current river management for the lower River Rhine focuses on enhancing the discharge capacity and biodiversity of the floodplain areas. There is no doubt that the different landscaping measures being proposed or implemented to fulfill these objectives have a significant impact on the morphological and hydraulic conditions and, therefore, on the sediment trapping potential of the floodplains. To assess the effects of these measures on sediment transport and retention in the lower Rhine floodplains, detailed quantification of the sediment deposition rates and patterns is needed.

To quantify contemporary sedimentation rates and patterns on the floodplains along the main branches of the River Rhine in the Netherlands (total surface area = 399 km^2), a two-dimensional floodplain sedimentation model was adopted at the scale of the entire Rhine delta. The model consists of two components: 1) the hydrodynamic WAQUA model that simulates the two-dimensional water flow patterns and 2) the SEDIFLUX model that simulates sediment transport and deposition. The model was run for 13 steady state discharge stages between 3500 m^3 s^{-1} and 16000 m^3 s^{-1} at Lobith near the German-Dutch border. Model parameter values of sediment settling velocity (6.7 10^{-5} m s^{-1}) and critical bed shear stress for sedimentation (2.0 N

m^{-2}) were assigned based on previous modelling studies. The annual average sediment deposition rates were calculated using the discharge frequency distribution for the 1901-2000 period and a sediment rating curve derived for the 1970-2006 period. The model results show that the average annual accumulation rate of fine sediments on the floodplains along the Rhine branches in the Netherlands is 1.91 kg m^{-2} y^{-1} or 610 million kg yr^{-1}. This corresponds to a conveyance loss rate of 44% for discharges greater than 3500 m^3 s^{-1} and 25% of the total annual suspended sediment load. These numbers are greater than those previously reported for lower River Rhine floodplains, which can largely be attributed to the fact that this study also considered sediment deposition at discharges less than 5000 m^3 s^{-1}. However, a large proportion of the sediment at the lower discharge stages is deposited in areas where the bed shear stress exceeds 2 N m^{-2} once a year on average (total 157 million kg y^{-1}). Therefore, it is likely that part of this sediment is resuspended and transported downstream during annual flood events.