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Examination of the declining trend in suspended sediment loads in the Rhine River in the period 1952-2016

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It has widely been reported that sediment loads have decreased drastically in rivers worldwide during the past decades due to human intervention in the upstream river system. These interventions include the construction of rivers and dams, sediment mining, and flood protection and soil conservation measures. The decreased sediment loads to the downstream deltas and coasts are a major cause of loss of land in deltas due to coastal erosion and uncompensated land subsidence and sea level rise. The Rhine River is no exception and also conforms this global trend of declining sediment load. To quantify this declining trend of suspended sediment loads in the Rhine River, we re-examined the annual suspended loads at the Lobith monitoring station near the Dutch-German border for the period since the start of the start of regular monitoring of suspended sediment concentrations (SSC) in 1952 until present (2016).

We combined measured discharge and suspended sediment concentrations to estimate daily sediment loads. Since 1989, measurements of both discharge and SSC are available at a daily time interval. For the pre-1989 period, only bi-weekly SSC measurements are available. Here, we estimated daily suspended sediment concentrations based on daily discharge measurements using the rating curve method. The rating curve parameters were estimated using log-log regression with a bias-correction. The rating curves were fitted for periods of about 5 years. The estimated daily suspended sediment loads were summed for each year to obtain annual loads. Annual discharge-weighted average SSC were calculated by dividing the annual suspended sediment loads by the total annual water discharge.

The suspended sediment loads show a declining trend from about 4×106 t y-1 in the early 1950s to about 1.2×106 t y-1 in the late 2000s. This corresponds to a decrease by 70%. Since about 2005, the sediment load seems to have stabilised around this value. The discharge-weighted average suspended sediment concentrations shows a similar, but more consistently declining trend between 1960 and 2005.

A closer inspection of the fitted 5-year rating curves reveals the decline in average SSC becomes particularly manifest at low discharges: SSC at low flow have decreased from about 40-50 mg/l to less than 20 mg/l in recent years. Major shifts in the sediment rating curves occurred around 1980 and around 2000. The substantial lowering of the rating curve between the 1975-1979 and 1980-1984 periods may probably be attributed to the construction of the upstream Iffezheim weir in 1977. The cause of the reduction of the rating curve around 2000 has not been identified yet. Considering the changes in the rating curves, the cause must likely be sought in an enhanced retention in the river channel network during low flow periods rather than in increased sediment trapping in floodplains or decreased sediment supply during hydrologic events. The identification of the precise causes will be subject of future study.