Implications of spatial distribution of suspended sediment concentrations on reservoir management, case study Iffezheim

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Introduction: Temporal and spatial variability of sediment deposition in reservoirs influences reservoir management strategies, e.g. dredging frequency or choice of dredging technique. Sediment deposition in general depends strongly on the sediment input from upstream.

In the case of the Iffezheim reservoir at the Upper Rhine river in Germany, the main area of deposition is located in the weir channel, i.e. downstream of where total inflow to the reservoir is divided between channels leading to the weir and to the hydropower plant, respectively [1]. Discharge division between the channels is dependent on power plant intake and varies with inflow from upstream (hydrology) and power plant operation (turbine load).

The bifurcation is furthermore located downstream of a distinct river bend. As a results, suspended sediment concentrations (SSC) show distinct lateral gradients [2].

Temporal variability of sediment available for deposition within the weir channel therefore depend on both sediment inflow from upstream and reservoir operation.

The objective of the study is to determine the degree to which suspended loads in the weir channel are influenced by reservoir operation.

Methods: ADCP measurements of flow and SSC are used to calibrate and validate the 3D hydrodynamic model SSIIM, computing combined suspended sediment concentrations and deposition pattern in the reservoir [3]. The calculations gave the spatial variation of these parameters as functions of the water discharges through the hydropower plant and the weir channel.

Temporal variations of inflow water and suspended sediment discharge (determined by a rating curve) from upstream and reservoir operating manuals are used to calculate average annual sediment input into the weir channel.

The sensitivity to changes in the power plant operation and in the degree of deposition within the reservoir is investigated by additional model runs.

Results: There is good agreement of measurements and model results on suspended loads within the weir channel. Both measurements and simulations show that, on average, due to the lateral gradients in SSC a higher portion of sediment than water is diverged to the weir channel. This difference gets more pronounced with higher discharges, but the effect is reversed during low discharges.

Power plant operation is shown to have significant influence on the suspended load division. Changes in bathymetry influence suspended load division to a lesser extent.

Discussion: Modifying reservoir operation, in general, can be a means of decreasing reservoir sedimentation [4,5]. A recently implemented additional turbine in the Iffezheim hydropower plant, resulting in a change in average flow division, will potentially affect sediment deposition in the weir channel of the reservoir, as sediment input, i.e. availability of sediment, is very important to deposition.

On the other hand, hydraulic conditions also significantly influence deposition probability. Changes in reservoir operation not only influence spatial distribution of suspended loads, but also influence bed shear stresses, determining deposition and erosion probabilities.

So, on the one hand, deposition volumes may be expected to decline if more sediment is diverged from the main area of deposition by modified reservoir operation. However, if hydraulic stress simultaneously decreases in these areas, deposition probability of the remaining suspended load may increase, counteracting the effect of a lower amount of sediment available for deposition. The interaction between these effects is object of ongoing research.

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