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3D hydro-morphodynamic models as support tools for obtaining sustainable sediment management strategies of reservoirs

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Reservoir sedimentation reduces not only the available storage volume of reservoirs, but may also create other serious problems, such as an increase of bed levels or accumulations of nutrients and contaminants, which affect the environment. An increase in bed levels at the head of the reservoir can reduce flood safety and increase the risk for the surrounding areas. Deposited sediments close to the dam may block hydraulic structures, such as the bottom outlets, or, in case they enter the intake, lead to possible abrasion of plant components (e.g. wear of turbines and pipes).

Prior to reservoir construction, a pre-evaluation of the sediment yield from the catchment is usually performed by using soil erosion and sediment delivery models. However, the trapping efficiency is often only obtained by empirical approaches, such as Brune's or Churchill's curve, which are based on the capacity of the reservoir and the mean annual inflow. This is still common practice, although 3D hydro-morphodynamic models became powerful tools to numerically study sediment transport and reservoir sedimentation prior to the construction of reservoirs as well as during its operation.

Within this study, a fully 3D hydro-morphodynamic numerical model, based on the Reynolds-averaged Navier-Stokes equations, is applied to a case study to simulate, on the one hand suspended sediment transport within a hydropower reservoir and on the other hand a reservoir flushing operation as potential management scenario, with the goal to remobilize already deposited sediments and to release these sediments from the reservoir. The modeled reservoir has a total storage capacity of around 14 million m^3, whereby the water level can fluctuate due to pumped-storage operation by 40.5 m (difference between the maximum operation level and the operational outlet). At the head is the natural inflow of two creeks into the reservoir and a lateral transition tunnel is located on the orographic right side, which collects several headwater streams from adjacent catchments.

Simulations are performed for different operation modes of the reservoir. The results clearly show that through active reservoir management (variation of water levels as well as using the momentum of the discharge from the transition tunnel) the sediment motion in the reservoir can be affected to a certain extent. It is for instance possible to almost completely avoid reservoir sedimentation in front of the dam and the hydraulic structures (water intake and bottom outlets) during sediment-laden flows when simultaneously high discharges are provided from the laterally

located transition tunnel. The conducted simulation results of reservoir flushing also show that the success of the flushing operation is strongly dependent on the water level. As expected, flushing with full drawdown of the water level is the most efficient method to release sediments.

Through the detailed results of the 3D hydro-morphodynamic model, it is feasible to receive a deeper knowledge of the ongoing sediment transport processes within the studied reservoir. The gained knowledge can further be used to derive sustainable and efficient management strategies for the sediment management of the reservoir.