Sedimentation in Passauna reservoir

Hydro acoustic measurements for the creation of bathymetry, and detection of sediment charactersitics and sediment mass.

Context

The construction of dams always causes a disruption of ecosystems and a massive change in the local and regional environment and their related ecosystem services. The previously transported organic and inorganic material stays within the reservoir up-stream of the dam, settles and accumulates as sediment. One consequence is the loss of storage volume. This storage volume loss leads to an increased vulnerability of the reservoir operation (e.g. during draughts). Due to a lack of sediment information (quality and quantity), the management options for the responsible operators are strongly limited. Improved sediment information about exact location and mass of sediment in the reservoir would provide critical insights for short- and long-term decision making and hazard prevention.

Objectives/Goals

- Assessment of actual storage volume
- Definition of sedimentation rate
- Spatial distribution of sediment thickness
- Calculation of storage volume loss

Method and Equipment

The sediment was ensonified using two single beam echosounders. The combination of the EA400 (Kongsberg) with 200 & 38 kHz and the SES 2000 compact (sub-bottom profiler, Innomar) with adjustable 4 to 12 kHz allows for the collection of detailed acoustic information of the sediment (Fig.1). Together with sediment samples (cores and grabs), which are analysed in the laboratory for sediment density. All information is stored with high precision GPS reference. For validating the hydroacoustic measurements, apart from the core sampling, also a dynamic penetrometer (GraviProbe GP) was used at around 130 locations to measure the sediment thickness. The GraviProbe is a heavy dart equipped with pressure and acceleration sensors. It can penetrate the sediment until the first strongly consolidated layer. Using the GraviProbe, transversal as well as longitudinal profiles of Passauna Reservoir were collected (Fig. 2).

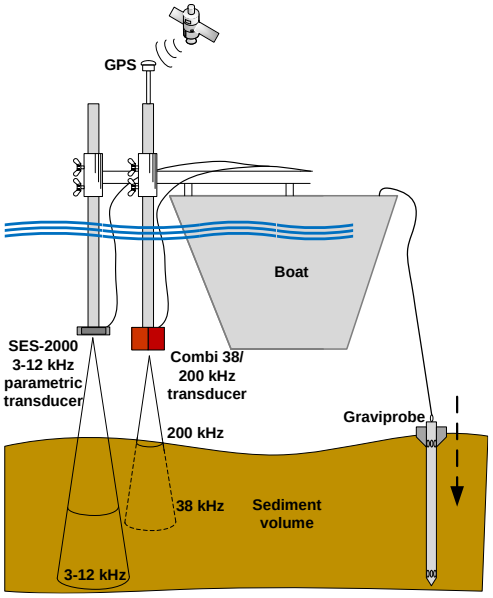

Fig. 1 Setup of the acoustic measurement system and application of the GraviProbe

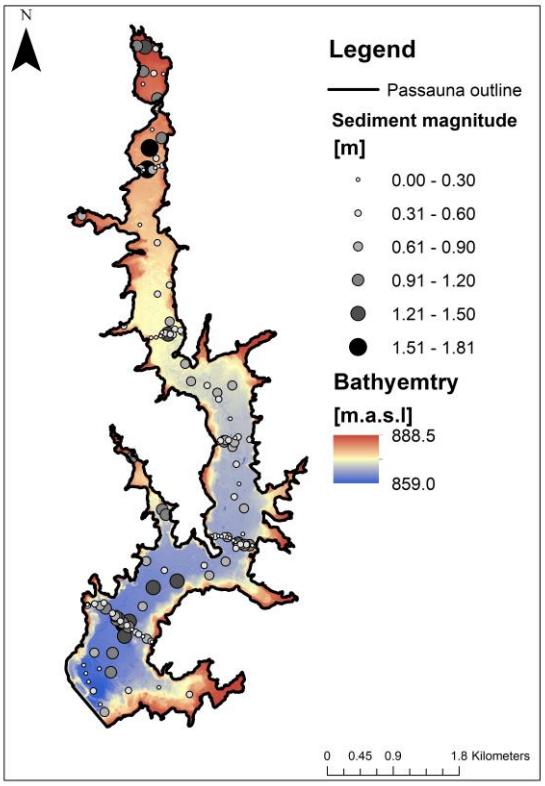

Fig. 2. Locations of GraviPrope measurements with sediment magnitude at the corresponding location, multibeam bathymetry in the background

Results

According to the EA400 results the deepest spots of the reservoir is the area with the highest sediment accumulation. In these parts of the reservoir the sediment thickness reaches around 1 meter and in some cases until 1.6 m. The shallow areas of the reservoir seem to have a lower sediment accumulation, reaching values until 0.6–0.7 m. In total at least 3,700,000 m³ (0–4 cm/year) of the total volume is lost due to sedimentation based on acoustic measurements. This corresponds to a volume loss of around 5%. The validation measurements with the penetrometer show a volume loss of 3,400,000 m³ (0–6 cm/year). Especially the maximum sediment thickness in the deep part was almost twice the sediment thickness derived from the hydroacoustics. In the shallow parts, the GraviProbe measurements prove the presence of high sediment thickness at specific locations but not in the entire coverage of the reservoir as the hydroacoustics show.

Discussion

Comapred to the overall reservoir sedimentation rate in the world(~1% per year) Passauna has a rather small sedimentation rate. However this study indicated that

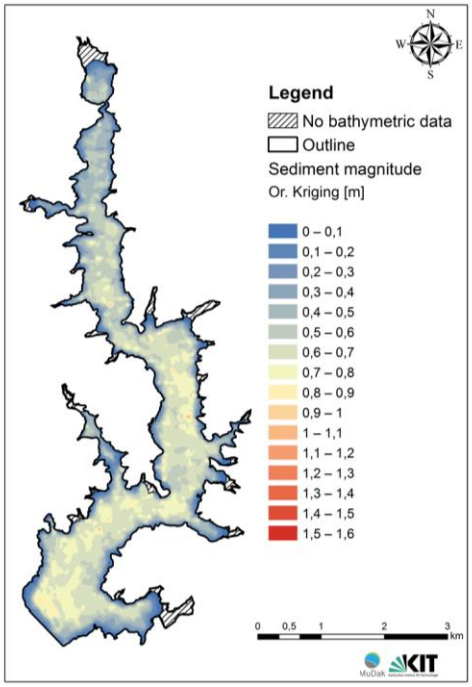

Fig. 3. Spatial distribution of sediment thickness in the reservoir from hydroacoustic measurements

the sedimentation rate is larger than previously calculated from Sauniti et al. 2004 (up to 3 cm/year)

Regarding the discrepancies in the results of hydroacoustics and GraviProbe, the main reason seems to be the high gas content in the sediment, as the gas is creating a barrier for the sound waves limiting penetration. Especially in the deepest parts this effect is evident. Furthermore, in the sediment budget of the reservoir, the sediment volume of the inflow part of the reservoir

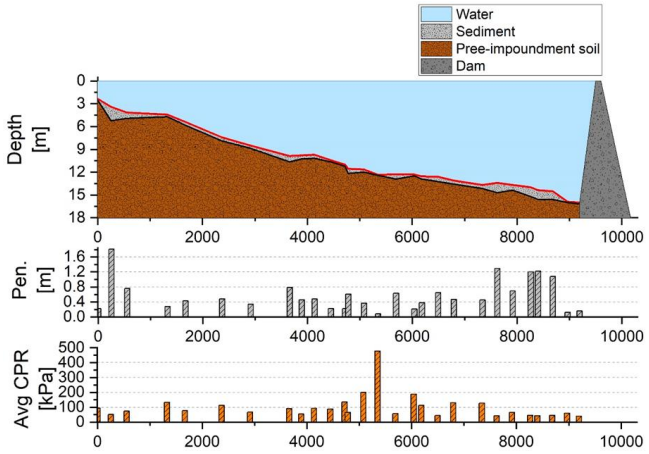

Fig. 4. Longitudinal profile of sediment thickness (top), penetration depth of graviprobe (middle), and hardness (down) in Passauna reservoir

(buffer) is not included. Precise measurements of sediment thickness in such a large spatial scale are challenging. Therefore a combination of techniques is needed for increasing the performance. Despite the mentioned errors, we managed to calculate a sediment budget of the reservoir with satisfying accuracy.

Innovation/Outlook

- ✓ High precision sediment mass estimation
- ✓ Improved information for dredging or remobilization measures
- ✓ Potential use of dredged sediments can be assessed, e.g. construction material, fertilizer
- ✓ Reduced costs for all underwater measures
- ✓ Secure long-term planning for the reservoir operator
- ✓ Use of the sediment input and soil loss maps for future strategical planning and sustainable management of the watersched

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