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Ultrasound investigation of sediment depositions in hydropower reservoir - case study Banje, Albania

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The hydropower industry is facing serious challenges handling sediment hazards. In fact, the world's total storage capacity is continuously decreasing 1-2% per year due to the sedimentation of reservoirs. The necessity to act accordingly, implies choosing the proper sediment management strategy, as early as in the design phase, and to adapt the system on the sediment and water discharge inflows during the operation of the hydropower plant (HPP). To achieve this goal, a detailed monitoring strategy must be implemented.

Periodic bathymetric surveys are crucial for obtaining reliable information about the sediment deposition. The Banje reservoir is located in Albania, in the Devoll river valley, which is a catchment with approximately 2000 t/ (km^2 year) sediment yield. The reservoir was commissioned in 2016 and until now two bathymetric studies were conducted. The measurements were performed using a single beam echosounder with dual frequency (80/200 kHz) and the RiverPro RDI, a five-beam acoustic doppler current profiler (ADCP): one vertical beam working at 600 kHz and four 1200 kHz slanted beam. In addition, 22 sediment samples were taken from the reservoir bottom with an Ekman grab sampler.

Both the echosounder and the ADCP are ultrasound instruments; besides the registering of water depth, they also give information about the strength of the returned acoustic signal (i.e., the backscatter). It is well known that the backscatter is highly sensitive to different roughness and river or reservoir bed composition of the reflecting material. In addition to the regular depth measurement, this study aims to correlate the density and particle size distribution of the bed sediment samples to the corrected backscatter signal. Furthermore, combining the observed changes of bed position and the investigated sediment characteristics, details about the total sediment deposition are inferred. The signal intensity from both instruments was corrected by applying an updated ultrasound equation, which yield the corrected backscatter signal. The first and the second returns (i.e., echoes) to the echosounder were used as an input data, whereas the ADCP bottom track signal strength indicator (RSSI) was included in the equation. The recorded raw data was previously processed and smoothed, carefully filtering errors and outliers.

A good correlation was obtained between the sediment samples density and the backscatter signal from the second echo. The ADCP backscatter is reasonably correlated to the particle size distribution of the bed material, but only for reflecting flat regions. The corrected first echo showed abrupt changes which are most likely produced by roughness variability of the reflecting region.

The combining of ADCP and single beam echosounder enabled a detailed analysis of the sediment characteristics and depositions in the reservoir. However further research is necessary to efficiently discard the false data reflected from submerged vegetation, buildings and debris. In addition, frequency dependent returns may be exploited to investigate the sediment layer consolidation.