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Evaluation of suspended sediment concentrations, sediment fluxes and sediment depositions along a reservoir by using laser diffraction and acoustic backscatter data

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The construction of dams and reservoirs disturb the natural morphological behavior of rivers. A natural settling effect occurs due to the reduced turbulences and flow velocities. As a consequence, reservoirs fill up with sediments which results in a reduction of storage volume, influences the operation of hydropower plants and leads in several cases to flood protection problems. The sediment depositions in reservoirs are standardly evaluated by using bathymetric data, obtained by a single beam sonar from pre-defined cross sections or by an extensive evaluation of the reservoir bed by a side scan sonar. However, a disadvantage of this method is that it is not possible to evaluate the pore water content of the depositions, which may lead as consequence to an uncertainty in the measured amount of deposited sediments.

Given that a major part of sediments entering reservoirs are transported in suspension, sediment flux measurements along defined transects could give more reliable information on the settled amount of sediments and additional information on the sediment transport mechanism within the reservoir. An evaluation of the sediment fluxes is in practice often conducted by a single suspended sediment concentration (SSC) measurement in combination with a cross sectional calibration factor to take changes in the SSC along the transect into account. However, these calibration factors are often developed only for one specific in-situ condition and may give unreliable results in case that the boundaries change e.g. the hydraulic conditions. Hence an evaluation of the sediment fluxes along the whole transect would give a more reliable number for the amount of transported sediments through the reservoir. This information can afterwards be used to calculate the amount of settled sediments in different sections of the reservoir and the amount of sediments which will enter the intake.

For this study the suspended sediment transport within the Peñas Blancas reservoir in Costa Rica was investigated where huge depositions have been recorded since the reservoir was built. The SSC's were measured with a LISST-SL (Laser In-Situ Scattering and Transmissometry instrument) which is based on the laser diffraction method and measures simultaneously the SSC as well as the particle size distribution. The measured SSC's were subsequently used to calculate the sediment fluxes within the transects, based on the intensity of backscattered sound from an acoustic measurement device. The total amount of deposited sediments could be calculated from the sediment fluxes, obtained by moving ADCP measurements (Acoustic Doppler Current Profiler) along chosen transects and so an image of the amount of settled sediments could be drawn.

The results of this study show the advantage of using two highly sophisticated measurement devices in parallel to receive accurate numbers for sediment fluxes within reservoirs, which can in addition be used in further studies to develop management strategies to reduce sediment depositions.