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Managing sediment flushing through Stramentizzo reservoir: field measurements and 3D numerical modeling

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The operations of flushing at reservoirs are the most widely used methods for sediment release. The release of the material causes significant environmental problems in the downstream reach. These problems can be mitigated through a proper management of sediment flushing, checking the concentration and volumes of released sediments and optimizing it with the hydraulic conditions of the river downstream.
The entrainment dynamic and sediment transport is not entirely well understood, as it is biologically mediated. The scientific literature still has some gaps on the study of sediment erosion determined by flushing operations.
The purpose of this work is to give a deeper insight on the sediment erosion of a hydroelectric power basin plant that determine the solid discharge in the inlet section of the downstream reach and to simulate it using an original 3D non hydrostatic computational model.
The case study is Stramentizzo reservoir (Trentino-Italy), an artificial reservoir subjected to heavy sediment deposition the sediment extracted by sediment cores from, Trento, Italy.
Among the various factors to be considered for sediment entrainment there are also the development of the biofilm that stabilizes the surface of the bottom sediment and the dynamics of the breakage of the entrained sediment that inhibits the deposition of material moved.
Multiple sediment cores were sampled in the reservoir area, at different planimetric locations and water depths.
The tests of the resuspension of the sediment were carried out in a laboratory straight flume in which the cores were placed. Gradually increasing bottom shear stresses -corresponding to different flow rates- were applied to the core, until a significant erosion of the sediments took place (attainment of Resuspension/critical shear stresses τr). Erosion rate E was experimentally evalutated for increasing shear stress as the measuring time required to erode 2mm in depth of surficial sediment core.
Moreover also other analyses were performed, such as optical particle sizing, image analysis, and densitometry and organic content analysis, in order to characterize the benthic sediments.
The resuspension shear stress τr resulted greater than predicted by the Shields theory for non-cohesive materials. This phenomenon is caused by the presence of a biofilm which stabilizes the surface layer in a cohesive/adhesive manner. The erosion rate E(τ), has an increasing trend with the shear stress applied (τ), and its derivative with respect to τ, dE(τ)/dτ , decreasing with the depth of the eroded sediment layer, according to greater difficulty of erosion of the lower layers. During erosion process macro flocs tend to be entrained, and under certain stress induced by flow motion, tend to break and form micro-flocs. The latter have been characterized by settling tests and diameter analysis on sonicated sediment samples.
Results obtained by laboratory tests have been used to numerically simulate the erosion and transport of sediment in the reservoir, for different scenarios. An original three-dimensional numerical model was used, based on a semi-implicit finite difference and finite volume discretization of the 3D nonhydrostatic free surface Navier-Stokes equations, together with a k-epsilon turbulence closure and a second order accurate conservative transport scheme for the sediment transport.