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Numerical Study on Reservoir Sediment Management by Adding Excavated Sediment Downstream of Dams in Japan

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ABSTRACT

The nuclear energy situation has become unstable since the recent events in Japan's Fukushima power plants. The need for alternate clean energies which respect both human and environment is thus growing. This paper focuses on improving the integration of existing dams – which can be viewed as such an alternative– in the natural environment. Today, the main concern with dams is the loss of water storage capacity due to sediment accumulating in the reservoirs, and the resulting downstream ecological degradation. To restore the natural characteristics of the downstream reaches and reduce reservoir sedimentation, the accumulated sediments are being relocated down into the dam's tail water. This process is called sediment supply, and has been tested in Japan and other parts of the world. More study is required to enhance its effectiveness, and the present research thus offers a practical method to assess positive outcomes of sediment supply on the downstream ecosystems.

We employed two different models CCHE2D model developed by the University of Mississippi, and iRIC platform (International River Interface Cooperative) to simulate 2-D riverbed changes. It is shown through a 2-D numerical model of Nunome River that sediment supply positively influences the river's morphology, by generating riffle-pool structures and sand bars. Indeed, these patterns increase the channel's global heterogeneity, and create hydraulically favourable habitats for fish and its spawning environment. First, bed morphologies induced by sediment supply were designed according to field observations and aerial photographs, and validated by the 2-D model. Second, habitat suitability indexes were established to assess two life stages of fish. The first index was based on observations of mature Salmonid habitat preferences, and the second described the optimal spawning conditions of the Ayu Plecoglossus altivelis. Finally, bed stability was evaluated through a Shields analysis of sediment mobility.

The results clearly highlighted the increase of habitat quality in the sediment supply-induced morphologies. Additional results showed how optimal spawning conditions occurred for higher discharges, and how the use of coarser replenished material could improve both bed stability and spawning conditions.