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Editorial

Sediment Management: Hydropower Improvement and Habitat Evaluation

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It is predicted that 60% of all new energy investments over the next 20 years will be in renewables. It is estimated that new hydropower production will represent 25% of all new renewables, primarily due to the hydropower production potential of China, Africa, Latin America, and South-East Asia. Additionally, in Europe, a growth in hydropower production is aimed at to achieve the 2050 emission targets envisioned by the European Union. However, some of the future main economic, technical, and ecological challenges are posed by the deposition, treatment, and disturbance dynamics of sediments in river catchments, which significantly reduce the future market potential of hydropower [1]. Because of a lack of knowledge about these sedimentological challenges (e.g., a lack of process understanding), various and huge economical, technical, and ecological problems with great relevance for the hydropower industry, water management authorities, and society, are emerging.

The aim of this Special Issue is to address recent research in sediment management in river systems, focusing on hydropower improvement and habitat evaluation. The presented articles provide new insights for the technological, ecological, and economical optimization of hydropower management and novel approaches for sustainable sediment management in anthropogenic disturbed rivers based on (i) advanced process understanding, (ii) environmental impact assessments, and (iii) the development of new monitoring/modelling technologies.

For the first category—to derive an advanced process understanding—the papers of [2] Sindelar et al. (2020), [3] Reiterer et al. (2020), and [4] DelRio et al. (2020) are listed. Both articles (Sindelar et al., 2020, and Reiterer et al., 2020) are joint papers dealing with experimental studies of sediment dynamics and related sediment management at run-of-river hydropower plants in a representative gravel bed river. Both studies used a scaled physical model test. In Sindelar et al. (2020), the focus was on the delta formation process at the head of the run-of-river hydropower plant (RoR). In Reiterer et al. (2020), the effects of reservoir flushing on delta degradation were investigated. For both studies, the physical model consisted of an idealized river having a width of 20 m, a mean slope of 0.005, a mean flow rate of 22 m^3s^{-1}, and a 1-year flood flow of 104 m^3s^{-1}. The model scale was 1:20. For both experiments, five different grain sizes were used, covering a range of 14 to 120 mm at a 1:1 scale. The experiments were carried out under mobile-bed conditions at flow rates that correspond to 50%–80% of a 1-year flood HQ_1.

The flood aspect, in terms of sediment management, was the central focus of Sindelar et al. (2020). On the one hand, the study proved that the delta formation increases the flood risk at the head of the reservoir; on the other hand, the results showed that reservoir drawdowns at flood events of high probability were a promising strategy for enhancing sediment connectivity under the specified boundary conditions. The results of the flushing experiment by Reiterer et al. (2020) showed the possibility of remobilizing delta depositions by (partial) drawdown flushing within a reasonable period (about 9 h in a 1:1 scale). The erosion of existing headwater delta deposition (compare to [2]) was found to be retrogressive and twice as fast as the preceding delta formation process. A spatiotemporal erosion scheme points out these findings. This supports the strategy of a reservoir drawdown at flood events with high recurrence intervals.

Another study for improved sediment management in terms of hydropower use is presented by Del Rio et al. (2020), based on the case of the Chivor's Life Extension Project (CLEP), with a new intake system into La Esmeralda reservoir (Colombia). In the article, sediment dynamics studies were described first and later connected to the need of the hydropower corporation to extend the life expectancy of the Chivor Hydropower Project. The construction of a new intake system was developed under favorable geomorphological, geological, and hydrogeological conditions, and the project was being developed without affecting the current operation. The innovative project turned out to improve the state of the art and was the first of its class in Colombia. The integrative study from the process understanding to management approach in the watershed included the design and construction of new intakes, in order to extend the life of an existing 1000 MW (6% of Colombia's demand) powerplant for 50 more years, contributing to a sustainable energy supply for the future.

For the second category of articles in this Special Issue—the environmental impact assessments—the papers of [5] Hauer et al. (2020a) and [6] Hauer et al. (2020b) are presented. Both articles deal with a controlled drawdown beyond the operational level of the Gepatsch reservoir (Austria). Based on the awareness of the potential ecological consequences, an integrative monitoring design for the abiotic and biotic environment was implemented. On the reach scale, an awareness of the possible ecological consequences for fish is important. Here, an advanced set of ecologically oriented measurements is presented, and a novel integrative monitoring design is addressed. Based on the results of Hauer et al. (2020a), a detailed, event-based quantification of suspended sediments and changes in morphology, especially with respect to fine sediments, and analyses of the biological quality element fish on the reach scale along the Inn River were developed. On the local scale (Hauer et al., 2020b), the scientific pre- and post-event monitoring included measurements regarding the cross-sectional variability in turbidity and habitat-related turbidity, freeze-core sampling to obtain knowledge on fine sediment infiltration and an evaluation of the macroinvertebrate communities as well as fish egg development (salmonid incubation). The results of the sedimentological as well as biological investigations showed a minor impact due to the controlled drawdown of the Gepatsch reservoir on the downstream aquatic system. In addition, recommendations based on the findings of both studies regarding possible methods for reach-scale and local-scale monitoring are included in this Special Issue. In the third category—the development of new monitoring/modelling technologies—the article of [7] Tritthart et al. (2020) is listed. In this study, a novel prediction tool is presented as a component of the Habitat Evaluation Model (HEM), which allows the assessment of the ecological status of impounded water bodies based on environmental factors. The modelling approach correlates habitat suitability information with the predicted abundance of benthic macro-invertebrates. The main model parameters are the observed grain sizes and depth-averaged flow velocities obtained from a hydrodynamic simulation. The tool was developed and tested in three Austrian river reaches. Tritthart et al. (2020) found that the river lengths predicted to be ecologically affected by the impoundments were substantially shorter for mean flow conditions than previously assessed when employing a physical mapping approach. The differences disappeared for low discharge conditions. The numerical prediction tool allows performing a status assessment for various discharge conditions, which are potentially more representative of the annual discharge spectrum than those within the in situ-observable range. This property bears the potential to facilitate the recommendation of sediment management strategies in impounded river reaches in the future.

In conclusion, the presented Special Issue (SI) on "Sediment Management: Hydropower Improvement and Habitat Evaluation" shows different opportunities for how an improved process understanding can be implemented into strategic or numerical tools for reservoir operations. For strategic management, the findings of the SI allow a differentiated discussion concerning if and how hydrological thresholds can be implemented into management practice. On the one hand, a clear move forward concerning an optimization in flushing operations, due to an adjustment of a clearly defined hydrological threshold for flushing at run-of-the-river hydropower stations, was presented by [2]. On the other hand, in [6], it was presented how thresholds can be misleading in terms of the ecological evaluation of, for example, habitat specific turbidity. This complexity in management, however, needs to be further discussed from a legal perspective, how those new insights into sustainable sediment management can be transformed into practice. Thus, one of the next steps will be dedicated to transferring these various novel aspects of the Special Issue into guideline documents to achieve the overall aim of this Special Issue: an improvement for both hydropower operation and instream habitats due to sustainable sediment management.

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