


Editorial

# Ecohydraulics Modelling and Simulation

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Ecohydraulics, the interdiscipline of ecology and hydraulics, has been rapidly developing and receiving ever-growing attention both in hydraulic research efforts and in environmentally oriented professional and lay communities in recent years. Hydraulic solutions in the environment are the challenge of the next decades, facilitating the improved understanding of the hydrological and geomorphological impact on the hydraulic properties of flow and their influence on biota. Conceptual, mathematical, and numerical models play a substantial role in this research. The increasing computational power facilitates enormously refined spatial and temporal resolutions in simulations, resulting in solutions that provide more detail than ever before. Various grid and particle-based modelling tools and techniques are being applied to access both the natural phenomena and the impact of engineering measures on flow and natural habitats. Modelling studies on flow-biota interactions significantly contribute to our understanding of ecological responses to hydrological and hydraulic changes in natural and engineered water environments. Furthermore, technically improved and relatively low-cost remote sensing tools and technologies facilitate the collecting of refined spatial data on significantly larger areas, and thus provide high quality input data for modelling.

Between November 2020 and May 2021, six manuscripts were submitted for consideration to editorial examining and peer review by independent experts in the field of ecohydraulics. Five papers, including four research and one review paper, were accepted and published in this Special Issue, with an acceptance rate of 83.3%. Twenty-four authors from seven countries around the world contributed their interest and knowledge by highlighting the various aspects of modelling in ecohydraulics.

With only five papers in this Special Issue, a small number of challenging questions regarding the development and application of numerical models in ecohydraulics has been tackled. Nonetheless, the published papers testify to the great diversity of topics addressed under the term ecohydraulics. Although all papers are addressing modelling in ecohydraulics, none of the keywords have been repeated.

A brief overview of the published papers is presented below.

The review paper of Kvočka et al. [1] has exposed the lack of progress in river oil spill models and modelling, which have not experienced equivalent development compared to the tools and techniques intended for oil spills in marine environments, and discussed that the river-specific oil spill processes are still poorly understood. The only significant improvement has been achieved in the field of the decision support systems. After an overview of various types of riverine oil spill models, the authors emphasised the need for conducting experimental research on the basic physicochemical processes associated with oil spills in rivers, which would facilitate the development and validation of new and more sophisticated models. They also emphasised that offshore and particularly coastal marine models have been adapted for application in rivers, at least in the areas with dimensions requiring multi-dimensional hydrodynamic and transport simulations, while nothing similar is currently available for small non-navigable rivers. One of the focuses in the paper also pertains to the importance of linking the governing interconnected processes, hydrodynamics, and transport and weathering in the river oil spill models. Furthermore, the possibilities of applying remote sensing of oil spills were discussed, a feature that has



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seldom been exploited in the riverine environment, although it could be applied for both detecting oil spills and providing high-resolution field data that can be used as input data and/or for validation of models. They concluded with the suggestion that the river oil spill processes and models should be actively promoted in order to reach higher funding and consequently faster progress in the field that is strongly connected to the environmental and public health.

An example of successful remote sensing application in ecohydraulics is presented in the research article by Lama et al. [2]. The authors employed an unmanned aerial vehicle (UAV) equipped with a multispectral camera to obtain images of riparian vegetation (*Arundo donax*) along an abandoned drainage channel. They compared the computed Normalised Difference Vegetation Index (NDVI) to the ground measurements of the Leaf Area Index (LAI), from which the bulk drag coefficient in the channel was computed. Furthermore, they performed flow velocity measurements in several cross-sections of the channel for validating the predicted bulk drag coefficient. A detailed description of the employed equipment, measurements, and image processing is provided, which is followed by the NDVI computation procedure, its correlation to the LAI, and the determination of the bulk drag coefficient. The agreement between the bulk drag coefficients computed from the ground and from the aerial measurements was excellent, which confirms the applicability of multispectral image mapping obtained with UAVs for determining the flow conditions in vegetated channels. The authors concluded with the suggestion that multispectral aerial images could be applied for determining various other riparian and aquatic vegetation indices, for predicting flow dynamics in vegetated open channels, and for predicting mitigation scenarios in surroundings of vegetated watercourses.

The next paper by Štefunkova et al. [3] demonstrated the evaluation of the relationship between abiotic flow characteristics and the habitat quality in the mountain streams in Slovakia, in which brown trout was selected as a bioindicator and the Instream Flow Incremental Methodology (IFIM) was applied. The authors analysed the area-weighted suitability (AWS) in 59 reference stream reaches, in which they performed topographic survey and hydrometric measurements. Furthermore, the ichthyological survey of the reaches and the AWS determination is described in detail, with the determined correlations between the AWS and the reaches' morphological and hydraulic characteristics also presented. The fish cover width, maximum depth, 364-day discharge, average maximum reach depth, and catchment area to the last profile of the reach were recognised as parameters, with the highest correlation to the AWS. The results of this study can be further applied in both research and practical engineering regarding either river regulation or restoration, as the study introduced significant simplifications compared to the established procedures on determining the quality of instream habitats.

The following two research papers discuss the hydraulics of spillways and fishways. Ghaderi et al. [4] performed numerical simulations of flow patterns and energy dissipation with different configurations in pooled stepped spillways. They investigated the influence of the step-edge design and compared the hydraulic properties of flow by both applying the FLOW-3D CFD model and simulating simple and notched step-edges. After a thorough description of the theoretical relations, applied numerical model, computational domain, and model setup and validation, the authors provided a detailed analysis of the hydraulic parameters for various pool configurations. Flow patterns, velocity fields, pressure distribution, inception points of air entrainment, turbulent kinetic energy, and energy dissipation were analysed. Good agreement with experimental results and literature data was achieved. The notched pool configuration showed higher maximums in TKE, higher energy dissipation, and lower probability of cavitation compared to the flat pool configuration, with all these features being important factors in the spillway design process. Furthermore, the results also showed that the notched pool configuration may represent the favourable stepped-spillways in engineering practice.

In the paper by Novak et al. [5], the authors investigated a bottom-ramp fish passage by applying smoothed particle hydrodynamics (SPH). A close-to-nature fishway was simu-

lated by applying complex geometry with various sized elements (spheres and cylinders) included in the simulations in order to increase the bottom-roughness and to achieve fish-friendly flow patterns along the ramp. After the description of the SPH method and the DualSPHysics model, validation of the setup for the selected study site was presented. Good agreement with existing experimental and numerical data was achieved. The authors provided a detailed analysis of flow depths and velocities at various distances from the bottom. Among the new tools developed within this study, the area-velocity tool is the most applicable for further research on fishways. It facilitates computational and graphical presentation of the parts of each cross-section with velocities under the selected threshold, thus enabling the direct comparison of flow conditions to the ecological capacities of present fish. The newly developed tools and the SPH models will facilitate more sophisticated designing and analyses of close-to-nature fishways, accounting for the paths of various fish species and sizes, the size and frequency of resting areas for fish, and the areas of longitudinal and transverse flow.

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