Environmental flow assessment for a green small hydropower plant using hydraulic-habitat modelling with a focus on the benthic macroinvertebrate community

Shuyi Hu

School of Geographical Sciences, Faculty of Science and Engineering, University of Nottingham Ningbo China

Ningbo, China

School of Geography and Environment, Oxford University

Oxford, UK

Meili Feng

School of Geographical Sciences, Faculty of Science and Engineering, University of Nottingham Ningbo China, Ningbo, China

**Abstract:** The concept of Green Small Hydropower (GSHP) is crucial to the sustainable development of small hydropower plants in China. Satisfying minimum flow requirement is regarded as the most important criteria during the certification of GSHP. The central government has put forward strict enforcement to ensure the release of minimum flow for GSHP. Minimum flow is mostly calculated using hydrological methods such as Tennant method with no seasonal variation, these methods rely on historical flow data and are cheap and easy to apply. However, the direct application of hydrological methods without using local ecological data for calibration lacks ecological validity, hence might result in unsuitable minimum flow recommendations for the local aquatic community. Instead, hydraulic-habitat modelling (HHM) is assumed to generate more ecologically relevant and reliable environmental flow recommendations. Nonetheless, Benthic macroinvertebrates (BM), which are crucial in the aquatic food chain, have rarely been the focus in HHM studies. This is due to the limited knowledge about their preferences for physical habitat conditions and limited economic values of conserving single BM species. Furthermore, BMs have different habitat preferences among various seasons, and thus their suitable flow regimes might vary with season. In this study, we used the Jiufeng Reservoir hydropower plant, which is one of the first GSHPs in China, as an example to investigate the season-specific environmental flow requirements with a focus on the local BM community. This study conducted pseudo-two-dimensional hydraulic-habitat modelling that couples the one-dimensional hydraulic models HEC-RAS and CASiMiR with the microscale habitat model HABFUZZ, to derive the environmental flows downstream of Jiufeng reservoir in summer and autumn. Our study found out that the minimum flow set using the Tennant method (1m3/s) is within the suitable flow ranges for the local BM community both in summer (0.69 m3/s -2.6 m3/s) and autumn (0.85 m3/s-1.07 m3/s), supporting its suitability in the case of Jiufeng reservoir. Instead of minimum flow, it is the excessive amount of flows caused by the frequent flushing due to hydropeaking that poses a major threat to the local BM community, with the autumn community significantly less tolerant to high flow levels. The research in this study provides scientific supports to the GSHP assessment standard, suggesting a more diverse environmental flow criteria that incorporates both minimum flows and peak flows. Moreover, this research used a novel pseudo-two-dimensional hydraulic-habitat modelling approach that can be applied to other areas in addition to environmental flow studies, such as river restoration and hydropeaking.

**Key words:** benthic macroinvertebrate, environmental flow, green small hydropower, hydraulic-habitat modelling, minimum flow