Ecological flow calculations and evaluation techniques: Past, present, and future

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Abstract

Most countries worldwide are finding it difficult to make decisions regarding the utilization of water resources and the ecological flow protection of rivers because of serious water shortages and global climate warming. To overcome this difficulty, accurate ecological flow processes and protected ecological objectives are required. Since the introduction of the concept, ecological flow calculations have been developed for more than 60 years. This technical development has always been dominated by countries such as the United States, Australia, and the United Kingdom. The technical applications, however, vary substantially worldwide. Some countries, for instance, did not readjust the method because of a lack of understanding of the ecological effect or because they failed to achieve elaborate scheduling. Mostly, readjustments were not made because the users could not make their choices from among numerous methods for ecological flow.

This paper presents three research results based on a systematic review of 240 methods with clear connotation boundaries. First, the ecological flow algorithm was developed along with the scientific and technological progress in the river ecosystem theory, ecohydrological relationship, and characterization and simulation of hydrological and hydrodynamic processes. In addition, the basis of the method has evolved from the hydrological process of the ecosystem, hydraulics–habitat conditions, and social development interference to whole ecosystem simulation. Second, 240 methods were classified into 50 sub-categories to evaluate their advantages and disadvantages according to the ecological flow algorithms of hydrology, hydraulics, habitat, and other comprehensive methods. According to this evaluation, 60% of the methods were not suitable for further application, including the method based on the percentage of natural runoff. Furthermore, the applicability of the remaining methods was presented according to the evaluation based on the aspects of allocation of water resources, water conservancy project scheduling, and river ecological evaluation. Third, In the future, most developing countries should strengthen the guarantee of high-standard ecological flow via a coordination mechanism for the ecological flow guarantee established under a sustainable framework or via an ecological protection pattern at the national level according to the national system. Concurrently, a reliable ecological flow demand process should also be established on the basis of detailed investigation and research on the relationship between river habitats, ecological hydrology, and ecological hydraulics. This will ensure that the real-time evaluation of ecological flow forces the water conservancy project scheduling and accurate allocation of water.

Key words: Ecological flow; Hydrological methods; Hydraulics methods; Habitat simulation methods; Holistic methods