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NUMERICAL MODEL FOR FLOW THROUGH SUBMERGED VEGETATION REGIONS IN A SHALLOW LAKE*

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Abstract: Aquatic vegetation has a significant impact on water currents. To evaluate the effects of changes in the aquatic vegetation on water currents of different velocity, a 3-D hydrodynamic model was then developed by taking into consideration of the additional hydraulic resistance of the aquatic plants. The Navier- Stokes equations were then solved using the SIMPLE method and the $k-\varepsilon$ turbulence model. Calculations using the established models were used to forecast the vertical distribution of the horizontal velocity and horizontal flow under the transmission conditions of the South-North Water Diversion in the Nansi Lake. And comparative calculation for the flow velocity was also performed using the simplified method of assigning a high roughness coefficient to the lake bed in the same area. Results suggest that adding additional hydraulic resistance of the aquatic plants is feasible. The calculation errors between simulation result and the field observed data are smaller than 15%, while, those errors are up to 35% if the influence of aquatic vegetation is dealt with the simplified method.

Key words: lakes, numerical models, hydraulic resistance, aquatic vegetation

Introduction

In rivers and lakes used for water transmission, the hydraulic resistance of aquatic vegetation directly impacts the transmission volume, elevates the water fall, and causes a loss in the transmission of hydraulic power. Effects of wet vegetation on water flow and water hydrodynamics were studied for many years. Among these, numerical modeling is a usual method to reveal the effects[1-3]. The expressions and parameters used to estimate the hydraulic resistance of aquatic vegetation has large effects on the results of simulations[4-7]. In addition, most of the results were focused on the impacts of emergent vegetation[8-12]. As for the submerged vegetation, two kinds of methods were generally used in floodplain flow modeling and simulation[13-15]. One is adding drag force parameters to the equation, the other is enhancing the bottom roughness coefficient. However, the submerged vegetation growing under the water surface is flexible to bend down to some extent while water flows over, which causes the changes in flow velocity and hydraulic resistance. It is difficult to express the effects of submerged vegetation in rivers and shallow lakes through increasing bottom roughness or adding drag resistant coefficient considering the real height of simulated vegetation.

In this study, a survey of the physical and biological characteristics of the Nansi Lake including a flume experiment and field observation data was conducted to determine expressions and parameters that evaluiate the hydraulic resistance produced by emergent vegetation (reeds or *Phragmites australis* (*P. australis*)) and submerged vegetation (*Vallisneria denseserrulata* (*V. denseserrulata*), *Potamogeton crispus* (*P. crispus*) and *Ceratophyllum demersum* (*C. demersum*)). These values are then used to establish a 3-D hydrodynamic model capable of

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