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Comprehensive operation of the eco-hydrological processes in shallow macrophytic lakes

Hydrolink

COMPREHENSIVE OPERATION OF THE ECO-HYDROLOGICAL PROCESSES IN SHALLOW MACROPHYTIC LAKES

BY ZHIFENG YANG, YUJUN YI, XUAN WANG & XINAN YIN

Changes in natural hydrologic regime due to intensive human activities and climatic changes are largely responsible for the ecological degradation of shallow macrophytic lakes, and thus ecological water should be supplemented in order to prevent the drying up of the lake. In this study, we investigated ecological water supplement in Baiyang Lake, a typical shallow macrophytic lake in northern China. It is recommended that water should be supplemented simultaneously through the northern and southern routes to increase the hydraulic disturbance in the central lake area and the water quality near the entrance.

Lakes play important hydrological, ecological and economic roles in regulating runoff, mitigating flood and drought impacts, and ensuring safe navigation, adequate water supply, and a high-quality habitat for a wide variety of aquatic species, as well biodiversity and sight-seeing. In China, most shallow (average water depth: < 10 m) macrophytic lakes are located in the plains in the middle and lower reaches of rivers (Fig. 1), which are known as the most populated and economically developed regions in China. Changes in their natural hydrologic regime due to intensive human activities and climatic changes have been shown to be responsible for the ecological degradation of these shallow macrophytic lakes. It is noteworthy that even a small change in water level can have a substantial effect on the area and hydrodynamics of shallow macrophytic lakes. In conclusion, the ecosystems of shallow macrophytic lakes are particularly susceptible to changes in their hydrologic regime. More importantly, intensive human activities over a short period of time can bring about dramatic changes in the water demand of lake ecosystems, as well as in their water surface area, water environment, habitat quality, population and distribution of biological species, and the structure and function of lake ecosystems.

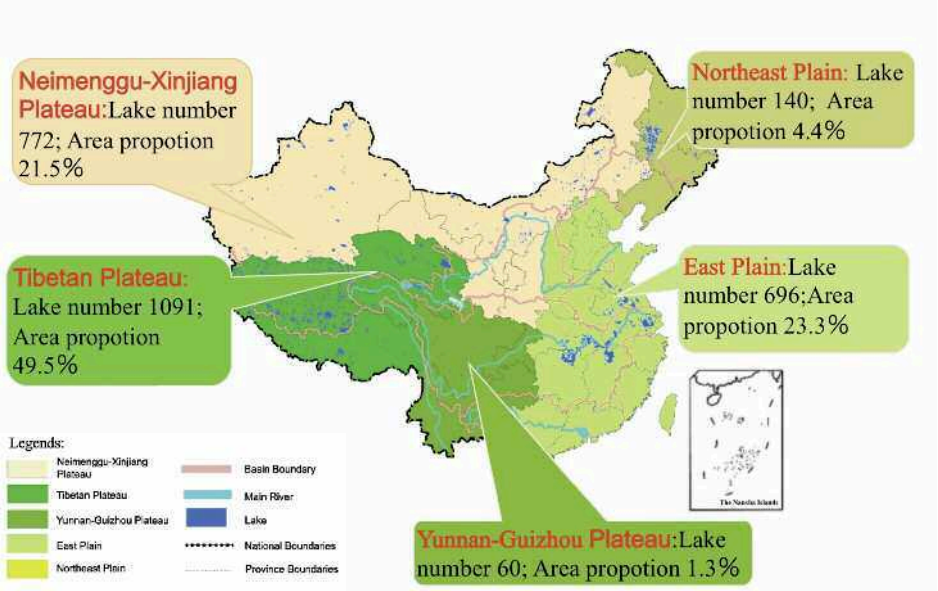

Figure 1. Geographical distribution of shallow macrophytic lakes in China

Three major problems faced by shallow macrophytic lakes

Three major problems may arise in shallow macrophytic lakes. First, shortage of ecological water can result in decrease of the lake area and, as a consequence, reduction in flood control and storage capacity and greater flood damage. For example, the inflow into the Baiyang Lake, the largest freshwater lake in northern China, has been reduced by approximately 55% in 2000 compared with that in the 1990s. The average annual inflow into the Baiyang Lake was about 240 million m^3 for the period 1980-2005, whereas that after 2000 was less than 50 million m^3 (Fig. 2). Thus, water has to be supplemented externally in order to prevent the drying up of the lake. Second, because of the effects of intensive human activities and global climatic changes, water resources management models for multi-purpose reservoir use, such as flood control, irrigation , power generation, industrial and domestic water supply, and emergency ecological water supplement, may fail to produce operational solutions that match the natural hydrologic regime characterized by low stable flow over a long period of time and a high flow pulse over a short period of time and the natural hydrologic process, thus resulting in the ecological degradation and reduced biodiversity in the shallow macrophytic lakes. Third, ecological restoration cannot be achieved merely by adjusting the structure of the lake ecosystems. Ecological water is often supplemented in emergency settings and it may conflict with industrial and domestic water demands. Thus, the effect of ecological water supplement can be greatly limited.

Ecological water supplement: A case study of Baiyang Lake in China

The evapotranspiration of plants, especially reed, is probably the most important cause of water consumption in Baiyang Lake. An optimization model was established for water resources management in Baiyang Lake, and

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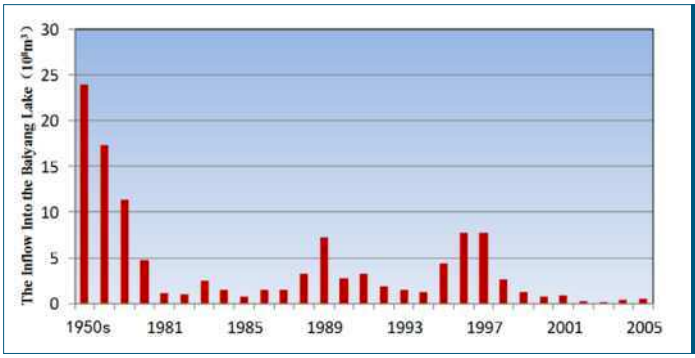

Figure 2. Changes in inflow into the Baiyang Lake

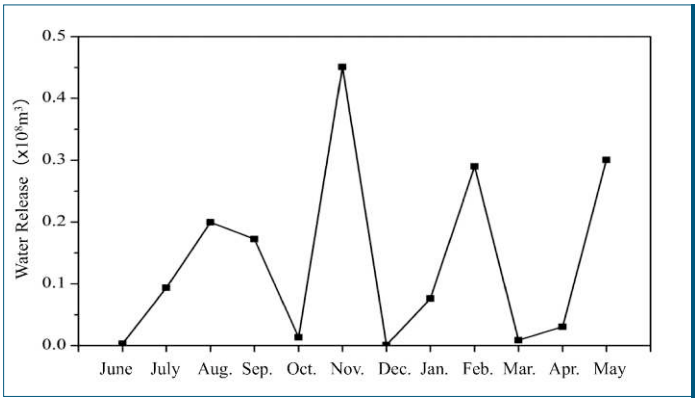

Figure 3. Ecological water supplement in Baiyang Lake

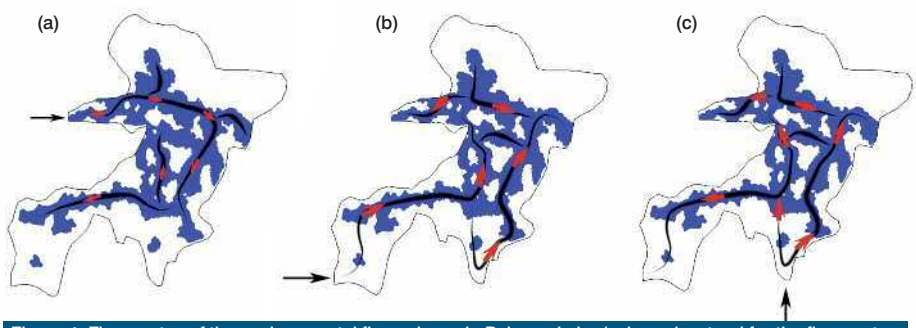

Figure 4. Flow routes of the environmental flow release in Baiyang Lake (a, b, and c stand for the flow routes of environmental flow released into the lake from Anxin, Hancun, and Dashuliuzhuang, respectively)

the results show that the optimal growth area for reed in Baiyang Lake is 91 km^2. The evapotranspiration of reed in its middle and later growth period far exceeds water surface evaporation, but the biomass remains largely unchanged during this period, indicating that only a small amount of nutrients are uptaken by reed. Thus, reed can be harvested some time ahead of its death, which can help to reduce unnecessary water consumption due to evapotranspiration. The water supplement to Baiyang Lake which takes into consideration the reed harvest is shown in Fig. 3.

It is clear that increasing the discharge of freshwater from upstream reservoirs contributes to the dilution of pollutants in the lake. However, the effects of different water supplement strategies on the water quality of Baiyang Lake remains to be elucidated. In order to better address this problem, a two-dimensional hydrodynamic water quality model was established. The simulation results showed that the area of Baiyang Lake affected by water supplement depends largely on the amount of water supplemented, the topography and the inflow rate. Water can be introduced into the lake through three routes, which can have different effects on local hydrodynamics and water environment. In order to more efficiently utilize the available water resources, water is preferably supplemented simultaneously through the northern and southern routes to increase the hydraulic disturbance in the central lake area and the water quality near the entrance (Fig. 4). ■

Our research group is looking for students and post-doctoral associates who are interested in the topic around environmental flow, eco-hydraulics, hydraulic modeling, and reservoir operation. Please contact us if you are interest in our work or join our group. Dr. Yujun Yi: yiyujun@bnu.edu.cn