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Ecological Engineering of Drawdown Wetlands Based on Water-level Fluctuation-Baijia Stream in the Three Gorges Reservoir as a Case Study *

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Abstract: The Three Gorges Reservoir (TGR) provides the benefits of flood control, electricity generation and improved transportation along the river corridor. For the purpose of flood control, the reservoir height varies between 145 m and 175 m above sea level, creating a reservoir littoral zone of about 350 km^2 in total area distributed along more than 1200 km of shoreline. Most of the littoral zone is flooded during October to May and relatively dry during the remainder of the year. Water level regulation has caused marked ecological changes in the littoral zone of TGR. The littoral zone formed after impounded by TGR not only is the crucible to us, but also the ecological opportunity. The vegetation of large-scale hydro-fluctuation belt is a very valuable resource, if properly used, can turn harm into advantage. In view of the current status and existing problems of the littoral wetland in TGR, we should focus on utilizing resources of the littoral wetland eco-friendly. Based on the needs for the littoral wetland transform into the multifunctional ecological economic benefit such as increasing carbon sources, biological production, and environmental purification, we must develop the ecological engineering model of sustainable utilizing the wetland resources of the littoral zone. In view of the environment problems of TGR and its characteristics of water level fluctuation, the ecological engineering focusing on restoration of littoral wetlands have been carried out since 2008. The ecological engineering was mainly conducted at littoral wetlands in Baijia stream of Pengxi River of TGR, including dike-pond system, submergence tolerance wetland-woods and waterfowl habitats recreate projects. The design principle and process for the ecological engineering of littoral wetlands restoration under the condition of the periodic water level change was described in details in this paper. Effects of the ecological engineering and the benefits to the environments were assessed. In the end of the article we proposed that the ecological engineering focus on the restoration of littoral wetlands, also should consider utilizing resources of the littoral wetlands eco-friendly.

Key words: water level fluctuation; littoral wetland; ecological engineering; Pengxi River; Three Gorges Reservoir
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The Three Gorges Reservoir (TGR) provides the benefits of flood control, electricity generation and improved transportation along the river corridor. For the purpose of flood control, the reservoir height varies between 145 m and 175 m above sea level, creating a reservoir drawdown zone of about 350 km^2 in total area distributed along more than 1 200 km of shoreline. Most of the drawdown zone is flooded during October to May and relatively dry during the remainder of the year. Water level regulation has caused marked ecological problems in the drawdown zone of the TGR[2-3].

The drawdown zone formed after impoundment of the TGR is not only a crucible to us, but is also an ecological opportunity. The vegetation of this large-scale hydro-fluctuation belt is a very valuable resource, if properly used, and can turn harm into advantage. In

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view of the current status and existing problems of the drawdown wetland in the TGR, we should focus on utilizing the resources of the drawdown wetland in an eco-friendly manner[4]. To this end, an ecological engineering model needs to be developed for the sustainable use of the wetland resources of the drawdown zone. The model should take account of the need to transform the drawdown wetland so as to obtain multifunctional ecological-economic benefits, such as increasing carbon sources, biological production, and environmental remediation. Since 2008 we have carried out ecological engineering studies focused on restoring the drawdown wetlands, taking account of the environmental challenges of the TGR and its characteristic water level fluctuation. The ecological engineering has mainly been conducted at drawdown wetlands associated with the Baijia Stream which feeds into the Pengxi River of the TGR. This engineering work has included projects on dike-pond systems, wetland woods that tolerate submergence, and recreation of waterfowl habitats. The design principles and project contents of drawdown wetland ecological engineering at Baijia Stream based on the water level fluctuations are outlined in this paper, so as to provide a reference point for the comprehensive management of drawdown zones of large reservoirs.

1 Situation of the Research Site

The Pengxi River is a tributary of the Yangtze River which lies in Kaixian, Chongqing[5]. It has 2 796 hectares of seasonally flooded land. The research site is located in the Baijia Stream which is a secondary branch of the Pengxi River. The region is characterized by north subtropical humid monsoonal climatic conditions with average annual precipitation of 1 200 mm and temperature 18.2 ℃[6]. The reservoir water level is managed such that it starts to rise in September and falls in April the following year. It is notable that the period between April and September is the best time for many plants to complete their growth cycle, and this fact is key to the success of the ecological engineering projects which are being attempted.

2 Basic Concept of Ecological Engineering under of Water Level Variation

There is a need to transform the drawdown wetland so as to provide multifunctional ecological-economic benefits, such as increasing carbon sources, biological production, and environmental remediation. To this end, an integrated model for using the wetland resources of the drawdown zone in eco-friendly ways should be developed. The model should focus on both the ecological protection of the drawdown wetland and the provision of economic benefits. This integrated ecological engineering approach includes dike-pond engineering, wetland-woods engineering, and waterfowl habitat reconstruction, all of which are focused on restoring drawdown wetlands and maintaining wetland ecosystem health. Through these ecological projects we aim to realize the eco-friendly utilization of drawdown wetlands and provide technical support for, and demonstrations of, ecological protection and reconstruction of the TGR drawdown zone.

3 Design Implementation of Drawdown Zone Wetland Ecological Engineering

3.1 Dike-pond engineering

Based on experience learnt from mulberry fish ponds in the Pearl River delta in Guangdong Province, ponds of different sizes, shapes and depths were dug in the drawdown zone of the TGR, and aquatic flowers, vegetables and crops were planted there[7-8]. These hydrophytes were planted after the water had receded in early April, and their management was carried out using eco-friendly approaches including not using inorganic fertilizers and pesticides. A significant benefit of a wetland system composed of dike-ponds is that the system provides an important ecological barrier between upland and the reservoir water body. The dike-pond system has the capability to act as a filter that reduces the flow of nutrients from the upland to the river system. During the growing season from May to September, these aquatic plants not only reduce water pollution, but also display colorful flowers that make the plants attractive ornamentals, thereby providing a potential resource for ecological tourism. By the end of September every year, these hydrophytes have completed their growth cycle and the economically valuable parts are then harvested before re-submergence. As a result useful biological products are obtained and some of the greenhouse gas emissions that would arise from anaerobic decomposition of drowned plants are avoi-

ded.

3.2 Wetland woods engineering

Trees and shrubs which tolerate seasonal submergence and have economic values have been selected for constructing woodland communities in the drawdown wetlands. The woody plants that have been selected for this wetland woods engineering are able to tolerate the severe environment of winter flooding. Until now, ten plant species have been selected, including: *Glyptostrobus pensilis*, *Taxodium distichum*, *Taxodium ascendens*, *Ascendens mucronatum*, *Metasequoia glyptostroboides*, *Sapium sebiferum*, *Morus alba*, *Debregeasia orientalis*, *Lycium chinense*, and *Tamarix chinensis*. Implementation of the project ranges in altitude from 160 m to 175 m. By taking a scientific approach to laying out these trees and shrubs in the drawdown zone, an ecological barrier has been constructed.

3.3 Engineering of re-created waterfowl habitats

Considering principles in bird ecology and ecological engineering, natural recovery should be the major measure for the re-creation of waterfowl habitats. Artificial constructions should be designed to produce sustainable habitats for waterfowl. Habitat elements that need to be considered for wetland birds include: food, wetland plant communities which provide shelter and nesting sites, bottom sediments, and diversity of habitats (such as ponds, ditches and depressions) which encourage bird diversity[9-10]. The main themes of projects for creation of engineered waterfowl habitats have been considered and include: design of habitat patches, micro-topographical reform, substrate transformation, construction of habitat networks, and reconstruction of hydrophyte communities.

4 Conclusion

This study is aimed at: exploring the ecological approaches to restoration and sustainable utilization of resources in the drawdown zone of the TGR; examining the construction of wetland ecological engineering projects under the specific conditions of the periodic variation of the TGR water level; and providing models and examples for the ecological protection and reasonable use of the TGR drawdown zone. Ecological engineering approaches being considered might minimize the impacts or enhance the provision of ecological services. Natural regeneration and ecological restoration in the drawdown area are valuable for decreasing soil erosion, reducing pollution, conserving biodiversity, increasing the carbon sink, and maintaining the ecosystem health of the TGR. By placing emphasis on ecological engineering approaches, such as dike-pond engineering and wetland woods engineering, protection and sustainable utilization of wetlands in the drawdown zone are promoted, and the ecological and economic development of society can be coordinated.

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