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To cite this article: ShengJie Li and Sichen Tong 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **643**
012092

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Progress and Prospects of Research on Ecological Impact of Channel Regulation Structure

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Abstract. Focusing on the aquatic ecological and environmental problems of waterway regulation structure, the research progress of waterway regulation structure on the physical and chemical properties of river water bodies, river benthic community structure and distribution and fish habitat was summarized, and the existing problems in current scientific research and engineering application were analyzed. Key researches were also put forward that should be carried out in the future for the protection of water ecological environment of waterway regulation structure including constructing and protecting the regional river ecological health index system in the waterway regulation building area and improving the construction of ecological waterway.

1. Introduction

The channel improvement structures adjust and control the water flow mainly by the improvement of buildings, stabilizing the favorable river regime, and improving the navigation conditions of the channel. Broadly, waterway regulation also includes reef blasting, dredging and straightening of bends^[1]. Generally the waterway regulation buildings are mainly including spur dike, longitudinal dike, bank revetment and closure dike. The construction of waterway regulation structure changes the physical and chemical properties of river water bodies and also affects the biogenic elements in the river by changing the species composition, habitat distribution and corresponding ecological functions of river ecosystem. The relationship among benthos, plankton and spur dike is shown in Fig.1. Therefore, the ecological and environmental effects of waterway regulation structure have become a long-term research hot-spot in water science and river ecosystems.

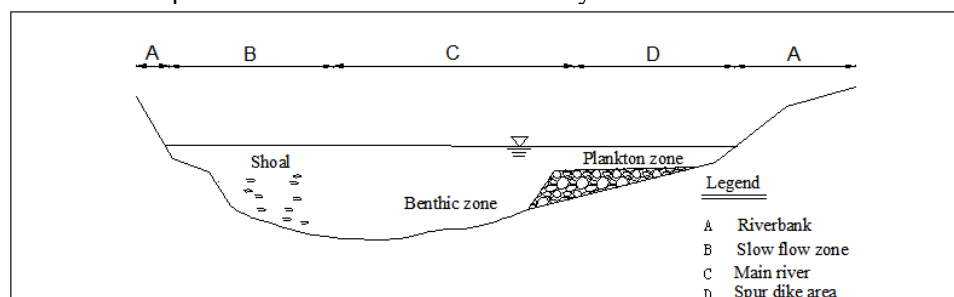


Fig.1. The relation graph among benthos, plankton and spur dike



In view of the physical and chemical characteristics of the water body, blasting reefs and damming can disturb the bottom quality of the river bed and the water body, so the sediment pollutants, suspended sediment particles and certain harmful chemicals produced by the explosion will dissolve in the water. It is revealed that the static water or slow flow area of the spur dike is suitable for the survival of benthic fauna with lower oxygen demand, while the rapid flow area is more suitable for the survival of aerobic benthic fauna. In view of the impact of waterway regulation structure on fish, the spawning ground of "four major Chinese carp" was emphatically studied. For some kinds of fish, ecological compensation measures such as enhancement and releasing and substitution of habitat structures were studied^[2-3]. Emphasis was put on the aspect of water ecological environment protection of waterway regulation structure^[4].

Although many researches have been carried out on the ecological environment effect and protection of waterway regulation, the ecological evaluation system on waterway regulation is still unclear. At the same time, due to the improvement of observation technology and the development and intersection of related disciplines and methods, some new phenomena have been gradually discovered and new mechanisms have been gradually revealed.^[5] Therefore, the waterway improvement and ecological environment protection still need to be explored further.

2. Influence of channel regulation project on the physical and chemical properties to river water

The waterway regulation project has changed the natural hydrological situation of the river. Reef blasting and damming project have the most significant influence on the physical and chemical properties of the river water. At the present stage, underwater drilling blasting is mostly used in reef blasting construction. The blasting process will disturb the bottom quality of the river bed and the water body, dissolving sediment pollutants, suspended sediment particles and certain harmful chemicals produced by the explosion in the water, resulting in turbidity and deterioration of water quality^[6]. After the reef is blasted, it would not only affect the sediment and flow conditions of the local reach but also affect the ecological quality of the river section. It will directly deprive the original excellent habitat for biological community aggregation and weaken the self-recovery ability of the reach after the completion of construction.

The setting of spur dikes would obviously change the hydrodynamic conditions of the the river section. The plane graph of the spur dike is shown in Fig.2. The mainstream area will become the a rapid area, and the back flow area in front of and behind the dam will become a slow flow area or even a static water area^[7]. During the operation period, the flow field distribution and water depth conditions of the reach are changed by the spur dam project, and the channel deformation and the streambed substrate are also changed. By measuring the flow field of the spur dike, Li Hong^[8] finds that when there is no spur dike, the water flow in the flume is smooth. The longitudinal velocity is much larger than the horizontal and vertical velocity, and the longitudinal velocity changes slightly along the way, basically reaching a uniform flow. When there is a spur dike, The flow field far away from the spur dike area is not much different compared with the non-dam but there is a difference in the influence range of the spur dike, especially near the spur dike. In the area of spur dikes, the back flow area is a very important water area in the setting of spur dikes and can be used as an important area of ecological compensation. Considering non-submerged spur dikes at different angles, a flume experiment conducted by Han Dongmei et al. ^[9] It is shown that the extent of the back flow region produced by the spur dike is greatly affected by the angle of the spur dike.

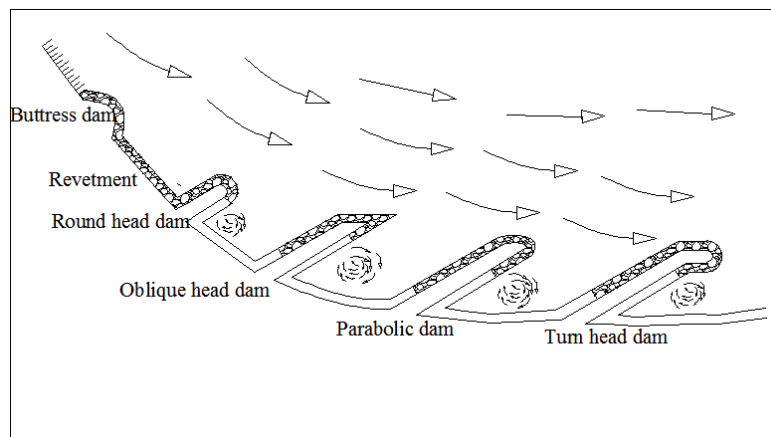


Fig.2. The plane graph of the spur dike

3. Influence of waterway regulation project on the community structure and distribution of river benthic fauna

Zoobenthos play an important role in material circulation and energy flow with long life span, limited migration ability, sensitivity and lagoon, so they are often referred to as indicators of long-term environmental changes^[10]. The growth and reproduction of macrobenthos are mainly affected by factors such as hydrology and hydrodynamics, water environment and physical geography. Tian Shimin et al.^[11] studied the coupling mechanism between the biodiversity of benthic fauna and the area of aquatic habitats, and analyzed the impact of water transfer on benthic fauna. Results showed that the number of benthic fauna increases with the increase of water surface area. The water depth is negatively correlated with biodiversity and biomass. Nelsin and Lieberman^[12] found that the flow rate is the main variable that affected the changes of benthic community structure. Since the speed of flow rate would affect the content of dissolved oxygen in water, the still water or slow-flow area of the spur dike was suitable for zoobenthos with low demand for oxygen, while the current area was more suitable for aerobic zoobenthos.

Differences in the structure, particle size, stability and organic matter content of river sediments will lead to differences in the community structure of benthic fauna^[13]. Pan Baozhu et al.^[14] studied the characteristics of the macrozoobenthos community in the Xijiang River and showed that the stabler the riverbed geology is, the more favorable the survival of the benthic fauna will be. The bottom quality of soft mud is mainly dominated by direct collector, while the scrapers or filter collectors are dominated by the various stone bottoms. The impact of the dumping of dredged sediments on benthic organisms is mainly manifested in the direct burying of benthic organisms to make them dead. Therefore, during the dumping of dredged sediments, the biomass of benthic organisms in the dumping area may decrease a lot in a short time. According to the data, most benthos live in the 30cm surface layer of sediments. If the dredging depth is 7~13cm, the benthos may recover after 15 days. If the dredging depth reaches 20cm, the benthos may not start to recover until 60 days after the dredging. If the bottom mud is completely removed, it may take 2 to 3 years to rebuild the benthic community, which is not conducive to the self-repair of the water ecology.

4. Influence of waterway regulation project on fish and its protection measures

The influence of waterway regulation on fish is mainly reflected in the protection and replacement of fish habitat. Thus, the safe distance under different explosive quantities can be determined. Taking the Daijiazhou River section as an example, Du Yunhui et al.^[15] studied the influence of waterway regulation structure on the spawning grounds of "four major Chinese carps". Results showed that the appropriate spawning velocity of "four major Chinese carps" would not be changed after the finish of the project and the spawning hydrological conditions (required by the existing spawning grounds of

"four major Chinese carps" would not be affected basically. Taking the Zhoutian reach of Jingjiang River as an example, Yi Liang et al.^[16] used a two-dimensional hydrodynamic model to study and showed that engineering operation would not have a great impact on the flow pattern of the spawning field. The submerged spur dam project will lead to the change of local flow rate and the scouring and silting of nearby riverbed. Some fishes that lay drifting eggs need a certain velocity stimulation and continuous flood during the spawning period, such as the spawning of "four major Chinese carps" in the Yangtze River. Therefore, based on the conventional ecological flow scheduling, the ecological pulse flow scheduling was proposed according to the needs of the special period. Chen et al.^[17] implemented physical model experiments and combined with years of field experimental scheduling data for the spawning field of "four major Chinese carps" in Yidu to determine the trigger flow rate, flow rate increase, and preferred flow rate of the spawning. According to the characteristics of the cross section, the initial flow rate to promote spawning of the four major home fish is 12500m³/s, the average daily flow rate increase is 1200m³/s (may vary from the irregular shape of the section), and the continuous water rise time is 4.5 days. The scheduling effect is remarkable.

Yang Qingrui et al.^[18] established an evaluation index system for the effect of habitat replacement of tributaries, including 4 primary indicators and 10 secondary indicators of hydrological situation, river water quality, biological community and physical structure. They adopted the evaluation method of analytic hierarchy process and expert rating, and tested the application of habitat replacement project of the Rosso River, a tributary of Lancang River. Gao Tianheng and others^[19] put forward corresponding suggestions and countermeasures for the different problems faced by the fish resources in the upper reaches of the Yangtze River: (1) reduce fishing intensity (2) further strengthen the management of protected areas (3) increase the species of reproduction and release.

5. Conclusion and Prospect

By sorting out and analyzing the research progress of ecological and environmental effects of waterway regulation structure in recent years, it is concluded that there are still several key problems that need to be further explored:

(1) The relationship between the layout of regulation buildings and biodiversity are expected to discuss in detail. Suggestions on the type and layout optimization of regulation buildings are expected to put forward.

(2) In the aspect of monitoring the river ecology and biodiversity of waterway regulation buildings, there are still certain technical difficulties left. The first is the typicality of river section of regulation buildings, and the second is the technical difficulty of sampling at different sampling points. How to sample the spur dike area and ensure safety needs to be further refined and considered.

(3) Regarding the construction of ecological waterways, relevant research is mainly reflected in the ecological restoration and management of rivers. Monitoring and review of the ecological environment of the waterways, including ecological revetment^[20], environmental dredging, dredged sediment utilization, and habitat reconstruction still need to be further studied^[21]. Little attention was put on the relationship between the construction of waterways and the functions of river ecosystems and there is no consensus on ecological waterways.

(4) Build and improve the ecological evaluation index system^[22]. At present, the research on aquatic ecology in my country is still in its infancy and lacks quantitative evaluation methods for ecological protection. There is an urgent need to build a complete ecological evaluation index system.

Acknowledgments

This work was partly supported by The National Key Research and Development Program of China (2018YFB1600400) and the Basic and Frontier Research Programs of Chongqing, China (cstc2018jcyjAX0534).

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