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Reconstruction of Hydrodynamics in Plain River Networks: Theory and Practice

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Introduction

The economically developed and densely populated plains of river networks consequently, issues with water security in river network areas are significant. These areas are frequently affected by typhoons, rainstorms, floods, and storm surges. The negative effects that humans have on the environment are getting worse as a result of today's rapid economic growth and urbanization. An unbalanced supply and demand for water, deterioration of the water environment, and degradation of water ecology are just a few of the new issues that are emerging in the plain river networks. It is challenging to manage and achieve sustainable social economy development in these regions due to the coexistence and intertwining of disasters involving water resources, the water environment, water ecology, and other water issues. The water administration idea of focusing on water preservation, adjusting spatial circulation, utilizing a deliberate methodology, and permitting full play to the jobs of both the public authority and the market forces better expectations for the natural insurance of water biology and for stream bowl/local multi-target framework administration. Managing water-related issues in plains with only conventional water resource allocation theory is challenging [1].

Description

Water security issues typically plague large river basins worldwide. For instance, intensive river improvement projects in the United States' Mississippi River Basin have resulted in the interception of a significant amount of sediment, a disruption in the water and sediment balance of the rivers downstream, erosion of the estuary and coastal wetlands, and the destruction of the ecology of the estuary despite improved flood protection. The Netherlands and other European nations have implemented a flood prevention strategy known as "Room for the River" that has resulted in a decrease in the number of floods that occur in the Rhine Basin. The rivers in the Rhine Basin have become increasingly polluted since the Industrial Revolution. Even though centralized treatment has been in place for nearly 70 years, there are still a lot of pollutants in the river sediment. The risk of water pollution is brought about by sediment erosion and suspension brought on by flooding in the river basin. The relevant nations are still trying to figure out how to completely manage flooding and keep the ecological water environment intact [2].

The Water Framework Directive was issued by the European Union at the turn of the century to direct the comprehensive management of water issues in river basins. Additionally, China has advanced from the initial stage of flood control to the current stage of comprehensive river basin management. It has been clarified that river basins are the fundamental unit of water resource management in China's Water Law, which was updated in 2002. However, there is still no comprehensive theory or method for integrated water management at this time. To achieve a balance between the quantity and quality of water resources, additional theory, method, and system research is required. Due to its gentle bottom slope and gentle terrain, a plain river network area typically exhibits weak hydrodynamics. Flow retardation and weakening are the results of anthropogenic disturbances like dense engineering projects that break the connection between the water systems. However, a plain river network area's hydrodynamic characteristics are closely linked to the complex water-related issues that arise there. The water body, for instance, deteriorates as a result of its low flow rate, which typically coincides with its low capacity for oxygenation and self-purification; specifically, the water quickly turns black and smells bad [3].

According to research, the rate at which microorganisms break down organic pollutants is directly impacted when river water has low dissolved oxygen content. The degradation of pollutants may also produce toxic substances and harmful gases (such as methane and hydrogen sulfide) that cause the water body to turn black and smell bad when the dissolved oxygen concentration is less than 2 mg. When the concentration of dissolved oxygen is greater than 7.5 mg, the water quality is deemed acceptable. Improvements in the hydrodynamics of a river network can enhance the re-oxygenation process, as flow conveyance is an important factor in determining a water body's dissolved oxygen content. In addition, the ability of the river to purify pollutants containing carbon, nitrogen, and phosphorus is enhanced to a certain extent by increases in the water flow rate, particularly in terms of lowering the chemical oxygen demand (COD).A water body's turbulence is more intense, pollutants are more likely to diffuse, and pollutants are more likely to be completely degraded by microorganisms when the water flows properly. This lowers the concentration of pollution in the water body.

The ecology of water is also affected by important parameters like flow velocity, water depth, and turbulence characteristics. The physiological and ecological behaviors of aquatic organisms like fish and benthic animals can be influenced by the flow velocity. Algae growth can be slowed by increasing flow velocity within a certain range. For the exact distribution of water assets, it is informal to carry out conventional water planning thoughts (e.g., weakening a dirtied water body with clean water) disregarding the significant job of hydrodynamics in working on the biological climate. Doing so doesn't adjust to focusing on water preservation in the new water the board period. Sluices, pumping stations, dams, spurs, and other water conservation devices can help correct the temporal and spatial imbalances in hydrodynamics that cause all of these negative water issues. The appropriate spatiotemporal hydrodynamic processes that are favorable to resolving these water issues result from these [4].

Plains have seen the construction of a significant number of sluices and pumping stations, resulting in a relatively complete water conservation system. The necessary means to control and improve the regional hydrodynamic field are provided by this. Gates, dams, pumps, and other devices are used to allocate water in the conventional water resource allocation theory and method. While secondary disasters may still occur, the application of these devices typically focuses on a single goal. Reconstructing favorable hydrodynamics in plain river networks poses numerous theoretical and technical difficulties. First and foremost, large-scale water conservation projects cannot be built on flat terrain. As a result, numerous small projects, such as pumping stations and sluices, are typically constructed. Second, rivers frequently traverse these plains, creating a chaotic and intricate internal water flow. It is

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challenging to identify a suitable hydrodynamic field for the entire substantial body of water. In addition, the boundaries are difficult to understand, and these regions typically lie close to large oceans and rivers. The internal and external hydrodynamic forces clash, resulting in unfavorable combinations that raise the stakes and increase the risks. Lastly, problems coexist, and the hydrodynamic requirements for resolving various water issues are not always mutually exclusive. A comprehensive theory and methods for hydrodynamic reconstruction are presented in this study. These are based on decades of research and engineering practices for managing plains water issues. Through joint management of sluices, pumps, and other water conservation projects, a theory for hydrodynamic reconstruction in plain river network areas is proposed. The resulting findings offer both theoretical and practical support for the comprehensive management of numerous water issues in plain river network regions [5].

Conclusion

In order to re-establish the desired temporal and spatial distribution of hydrodynamic forces, hydrodynamic reconstruction of a plain river network area refers to the storage and expansion of the limited water flow energy in the river network area (supplied by sluices, pumping stations, dredging, embankment, flood storage and detention areas, and other projects).This theory emphasizes the significance of hydrodynamics in safeguarding the ecology and environment of the water, in addition to the significance of the flow volume. The layout of systems for water conservation projects is designed to fully utilize projects' potential integrative benefits. The engineering technology system is designed to optimize the river confluence dynamics to minimize blocking, smooth the flows near the combined sluice–pump station, prevent erosion and siltation of the riverbed, and resolve other issues encountered in hydrodynamic reconstruction projects. It is based on the principles of controlling energy dissipation and effectively utilizing natural hydrodynamics. The proposed framework makes use of five technologies that have already been developed: Energy-saving and anti-siltation technology for coastal tidal gates, anti-scouring technology for a tetrahedral permeable frame group, flow power reconstruction technology for channel confluences, rectification and energy dissipation technology for combined sluice–pump stations, and a new type of sluice that can take in channel water without sediments.

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