
ORIGINAL RESEARCH ARTICLE

Research on water resources protection system in Minjiang River basin in the new period

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ABSTRACT

This paper put forward the idea of formulating the water resources protection system of the basin in the new period based on the new situation and new requirements. Taking the Minjiang River basin as the research object, taking its outstanding environmental problems as the guide, and taking the ecological function positioning of the basin as the basis, this paper proposed the water resources protection system of the Minjiang River basin under the new situation of ecological civilization construction.

Keywords: Water Resources Protection; Three Lines and One Single; Ecological Civilization; Spatial Planning; Comprehensive Basin Planning

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1. Introduction

Since the reform and opening up, China's economic and social development has made world-renowned achievements, but also paid a huge environmental price. In the past, we first had to solve the problem of "food and clothing", and some of the development and construction units had poor awareness of environmental protection and a weak concept of the legal system, and the pursuit of economic benefits was their first priority. The 19th Party Congress proposed that socialism with Chinese characteristics has entered a new era. At this stage, China should vigorously promote the construction of ecological civilization, carry out the pilot project of "multi-regulation", unify the planning system, and take the green development road of "ecology first". Under the new situation of ecological civilization in the new era, the direction of water resources development in the river basin is to lead economic and social development by planning, with ecological priority as the premise of planning and "three lines and one list" as the constraint^[1-3].

Due to the disorderly development of small hydropower in Minjiang River, unreasonable utilization of water resources and insufficient supervision in the past, many environmental problems have been left in Minjiang River basin^[4-6], and the protection of water resources in the process of development and utilization in the basin is more urgent and important^[7]. This paper takes the Minjiang River basin as a case study, analyzes the outstanding environmental problems in the Minjiang River basin, combines the requirements of the new situation of ecological civilization, and proposes a water resource protection system for the Minjiang River basin in the new era based on the ecological function positioning of the basin, provides theoretical guidance for

comprehensive planning and planning environmental assessment of the basin, and provides technical support for the development, utilization and protection of water resources in the basin. According to the analysis, the Minjiang River basin mainly has outstanding ecological and environmental problems, such as the ecological flow of some sections does not meet the requirements, the quality of water environment in the middle reaches of the river does not meet the standards, and the aquatic biological resources are seriously damaged. In view of the above environmental problems and causes, and based on the new situation of ecological civilization, the Minjiang River basin water resources protection should be led by planning, with ecological priority as the premise, “three lines and a list” as a constraint, coordinate the system management of watershed mountains, forests, fields, lakes and grasses, and strengthen the supervision of water resources development.

2. Minjiang River basin overview and data selection

The Minjiang River is a first-class tributary on the left bank of the upper reaches of the Yangtze River, originating at the southern foot of Minshan Mountain at the junction of Sichuan and Gansu Provinces, and after the Minjiang River, Dadu River and Qingyi River converged at Leshan City, its flow direction turns southeast and finally joins the Yangtze River at Yibin City. The Minjiang River basin covers an area of 135,400 km², involving Qinghai and Sichuan provinces, with a total length of 735 km, divided into upper, middle and lower reaches by Dujiangyan and Dadu estuary, with an average annual flow of 3,022 m³/s at the estuary, and its main tributaries being Dadu River and Qingyi River. The construction of water conservancy and hydropower projects in the basin has changed the natural runoff process of the river^[8], and with the intensification of human activities, a series of ecological and environmental problems have been triggered.

The hydrological stations of Zhenjiangguan, Pengshan and Gaochang in the main stream of Minjiang River were selected as representative stations in the upper, middle and lower reaches of the main stream, and the measured hydrological information

of the three stations from 1957 to 2016 was selected as the basic data information, combined with the report on the ecological and environmental conditions of Sichuan Province from 2012 to 2017, so as to analyze the main ecological and environmental problems in the Minjiang River basin.

3. Outstanding ecological and environmental problems in the Minjiang River basin

The Minjiang River basin is an important part of China’s “two screens and three belts” and an important ecological protective screen in the middle and lower reaches of the Yangtze River; it is also a major area for maintaining forests, grasslands and biodiversity in China; the lower reaches of the Minjiang River are an important channel for fish migration and exchange between the Minjiang River system, the Jinsha River and the Yangtze River system.

3.1 Serious ecological degradation in the upper reaches of the Minjiang River

Due to its special geographical conditions, coupled with the influence of the “foehn effect”, the river valley has a dry climate, poor soil, low vegetation cover, fragile ecological environment, and difficult to restore vegetation^[9]. Since modern times, unreasonable farming methods, overgrazing and logging, and geological disasters have seriously damaged the regional vegetation, reduced forest cover, destroyed alpine meadows, reduced water-holding capacity, resulting in serious soil erosion.

3.2 Some sections in the upper and middle reaches do not meet the ecological baseflow control objectives

The hydropower station of the upper reaches of the main stream of the Minjiang River are mainly small hydropower plants with high head and low gate dams, and existing hydropower development does not pay enough attention to ecological environmental protection, and the river takes continuous diversion development, which causes unreasonable scheduling when considering the release of ecological flow, resulting in low flow in the downstream river during the dry period in some periods, and

even leading to partial disconnection of flow in some sections of the river. This has led to environmental degradation^[5]. In recent years, with the improvement of environmental protection requirements, the situation of partial disconnection in the upper reaches of the main stream of Minjiang River has been ameliorated. From the actual annual aver-

age flow process of Pengshan hydrological station from 1957 to 2016 (Figure 1), the flow at Pengshan station has shown an obvious decreasing trend in the past 60 years, which is related to the gradual decrease of incoming water from the upper reaches and the gradual increase of water consumption in the middle reaches.

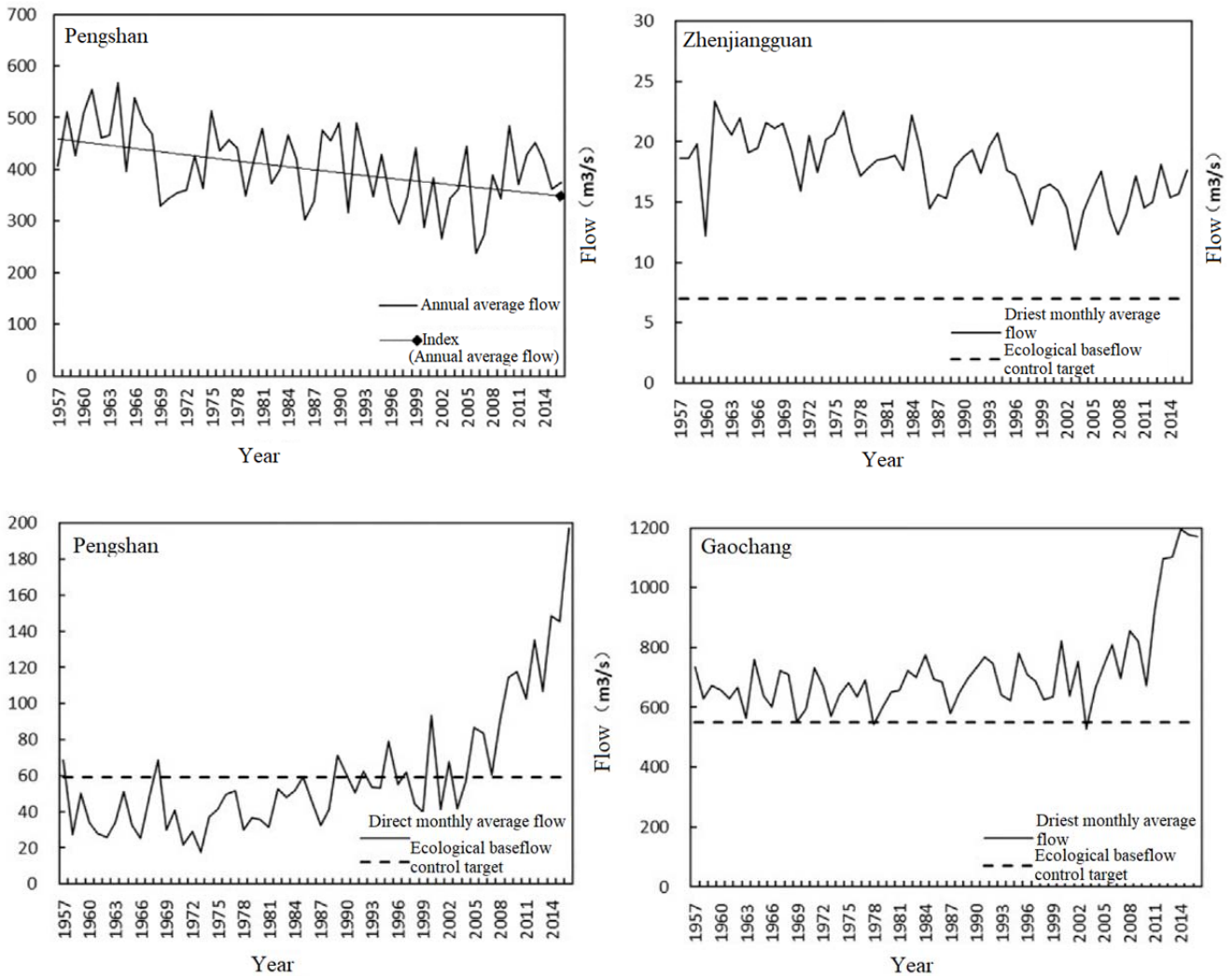


Figure 1. The average flow and the average flow of the driest month from 1957 to 2016 at the main hydrological stations of the Minjing River main stream.

According to the *Comprehensive Plan for Water Resources in the Yangtze River Basin*, the *Comprehensive Plan for the Yangtze River Basin*, and the *Comprehensive Plan for the Minjiang River Basin*, the ecological baseflow control targets for the Minjiang River mainstem cross-sections at Zhenjiangguan, Pengshan, and Gaoba are $7 \text{ m}^3/\text{s}$, $59 \text{ m}^3/\text{s}$, and $551 \text{ m}^3/\text{s}$ respectively. The most depleted monthly flow at the upstream Zhenjiangguan and downstream Gaochang cross sections can mostly meet the ecological baseflow requirements, while

the most depleted monthly flow at the midstream Pengshan station in most years before 2004 cannot meet the ecological baseflow control target requirements, and the unsatisfied period is mainly concentrated in the dry period from February to April. After Zipingpu Power Station was put into operation in 2006, due to its regulating effect, the discharge flow of Pengshan hydrological station in each month increased significantly compared with previous years, and all of them could meet the ecological baseflow requirements.

On the one hand, because almost all the water from the upper reaches of the Min River enters the Chengdu plain through the Dujiangyan intake during the dry period, causing the flow of Jinma River to reduce or even cut off during the dry period. The construction of Zipingpu has solved the problem of Jinma River cutting off due to the reserved ecological flow. On the other hand, the middle and lower reaches are the economic core area of the basin, and with the economic and social development and the continuous expansion of the population scale, the demand for water resources grows year by year. At the same time, the midstream area is distributed with several large and medium-sized irrigation areas such as Dujiangyan and Tongjiyan, and the continuous expansion of the irrigation area leads to a significant increase in agricultural water consumption. This has all led to a decrease in water resources in the middle reaches of the Minjiang River, and some sections do not meet the ecological base flow control target requirements. In recent years, these phenomena have been ameliorated, but with the accelerated construction of Chengdu Economic Zone and Tianfu New Area, the demand for water resources in the middle and lower reaches will further increase.

3.3 Low compliance rate of water environment quality in the midstream stem and tributaries

According to the bulletin of the state of the environment of Sichuan Province, from 2012 to 2017, the overall water quality of the main streams of the

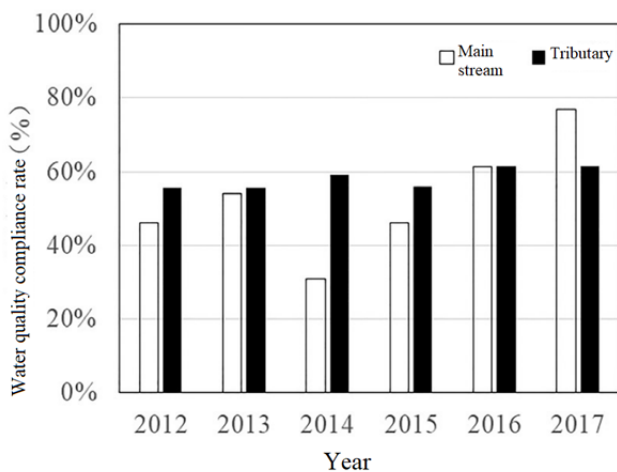


Figure 2. Minjiang River system dry and tributary water quality standards attainment rate in 2012–2017.

Minjing River was lightly polluted, and the overall water quality of the tributaries was moderately polluted^[10]. From 2012 to 2017, the overall water quality of the Minjiang River stem and tributaries showed improvement, with a significant increase in the rate of water quality compliance in the stem and a small increase in the rate of water quality compliance in the tributaries (**Figure 2**).

The proportion of class III and above of water bodies increased from 55.5% in 2012 to 66.60% in 2017, and the proportion of inferior V water bodies decreased from 17.50% in 2012 to 10.30% in 2017 (**Figure 3**). Water quality pollution in the mainstem is mainly concentrated in the midstream section of the river from the exit of Chengdu to the entry of Leshan, which is mainly polluted by total phosphorus, and some river sections have chemical oxygen demand and ammonia nitrogen pollution. The tributaries Xinjin South River, Jinniu River, Simeng River and Mangxi River are heavily polluted, and Fu River is moderately polluted, with the main pollution indicators being total phosphorus, ammonia nitrogen and chemical oxygen demand.

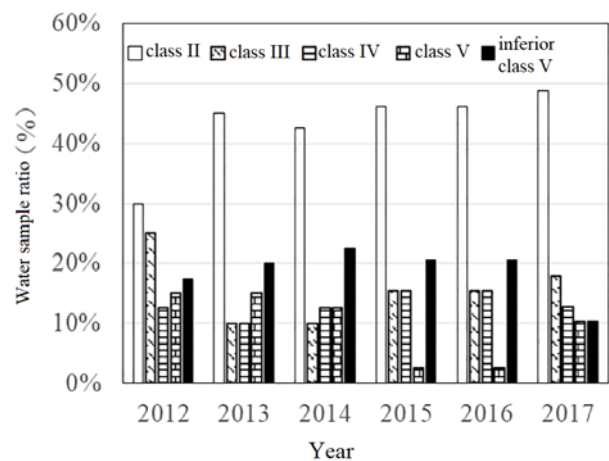


Figure 3. Proportion of water quality categories in the Minjiang River system from 2012 to 2017.

Insufficient water resources and high pollution intensity in the middle reaches of the Minjiang River are the main causes of water environment pollution in the middle reaches. The incoming water of the upstream of Minjiang River decreased year by year. Especially during the dry season, the cross sections such as Pengshan cannot guarantee the ecological base flow control target, and there were breaks of the flow in Fu River and Nan River, leading to the deterioration of water quality. The

middle and lower reaches are the core economic areas of the basin, and the large amount of domestic sewage and industrial wastewater discharged from the cities along the river has led to the pollution of the water environment in the middle and lower reaches of the Minjiang River, with domestic pollution dominating in Chengdu and industrial pollution in Meishan and Leshan.

3.4 Serious damage to aquatic biological resources in the basin

The aquatic biological resources in the Minjiang River basin have been severely damaged under the impact of small hydropower development in the upper reaches of the river, water reduction and water pollution problems in the middle reaches, and human disturbance in the lower reaches, and the impact of development of the Dadu and Qingyi rivers. From the whole Minjiang River basin, the national level I protected fish, white sturgeon and Chinese sturgeon have been extinct for many years, except for Dacian sturgeon, which is occasionally caught in the lower reaches of Minjiang River. The second-class protected fish, the Sichuan-Shaanxi Churro salmon, has been extinct in the upper reaches of the Minjiang River and the Qingyi River, and has also retreated to the depopulated zone above kyom-kyo tributary of the Dadu River, and is on the verge of extinction; the coelacanth has also not been caught for many years. Minjiang mainstem long thin loach, golden sand loach and other drifting egg-producing fish spawning grounds may have historically been distributed in the lower reaches of the river below Wenchuan and Mao county. At present, the Minjiang mainstem drifting egg-producing spawning grounds have retreated to the lower reaches of the Dadu River estuary.

4. The development ideas of watershed water resources protection system in the new era

The watershed water resources protection system in the new era should fully absorb the defects in the process of watershed water resources development and utilization in the previous stage, based on the functional positioning of the watershed, take the

outstanding environmental problems existing in the watershed as the target, and examine the watershed water resources development and protection with new requirements and views^[11-13]. Firstly, a scientific comprehensive basin plan is used as a guide to avoid environmentally sensitive factors from the source; secondly, the system management of mountains, water, forests, fields, lakes and grasses is proposed to coordinate the ecological and environmental problems with the content of the plan; thirdly, the supervision of the implementation of the basin plan and the system management measures is strengthened to ensure that the water resources development and utilization strictly abide by the red line of ecological protection, the bottom line of environmental quality and the upper limit of resource development and utilization in the basin (**Figure 4**).

4.1 Improve water resources protection system with planning as the leader

With national development planning as the leader, spatial planning as the basis, based on the new situation, new tasks and new requirements, we should make scientific preparation of comprehensive basin planning, improve the basin water resources protection system, so as to provide strong support for the development and protection of basin water resources. Basin water resources development should be led by comprehensive basin planning. Clarify the functional positioning of comprehensive basin planning and basin environmental protection and development positioning, take the spatial planning as the basis, comprehensively map the basin's territorial space background conditions, fully consider the basin's ecological function status and resource and environmental constraints. Scientifically delineate the basin's ecological space, develop the "three lines and one list", strictly adhere to the ecological protection red line, environmental quality bottom line and resource development and utilization limit line. Strengthen the control of space and major control lines, promote the comprehensive planning of the basin and planning environmental assessment to the ground, formulate and optimize the development pattern from the planning level, and avoid environmentally sensitive areas.

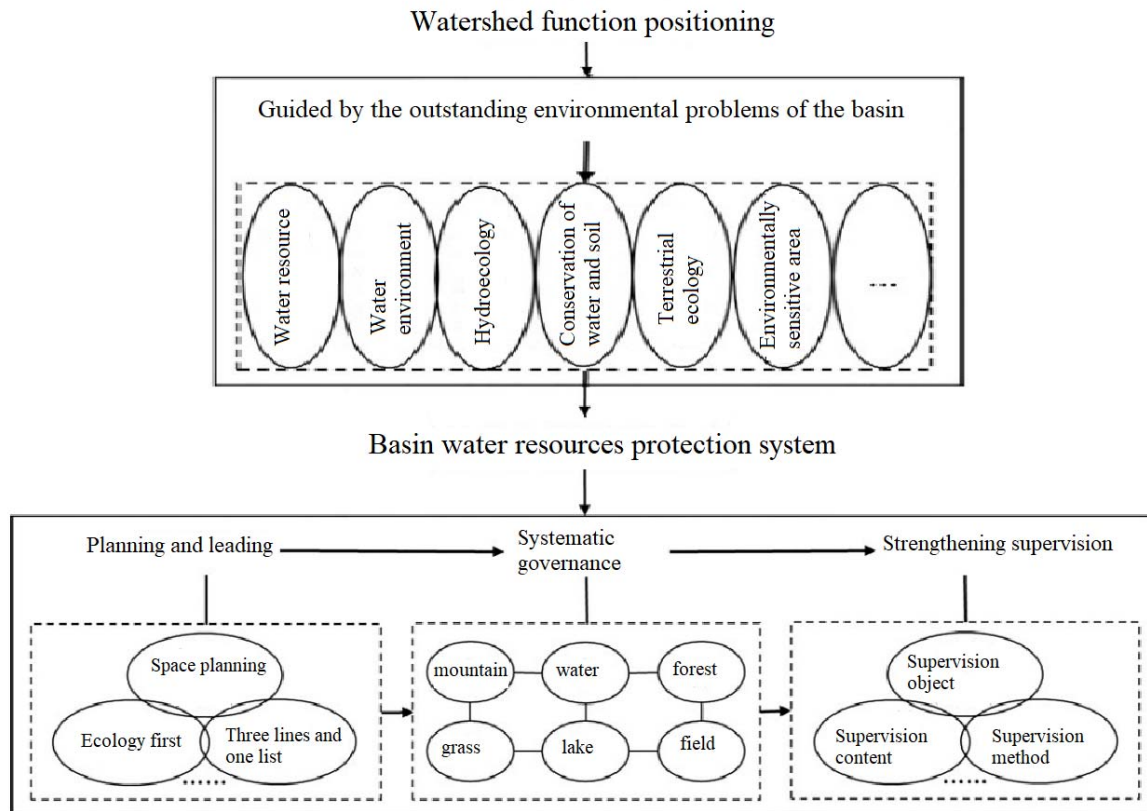


Figure 4. Basin water resources protection system structure chart.

4.2 Systematic governance of mountains, water, forests, fields, lakes and grasses to ensure ecological security

We analyze the outstanding ecological and environmental problems in the watershed in terms of water resources conditions, water environment quality, aquatic ecological environment, soil erosion management, water connotation function and biodiversity maintenance function, and the protection status of ecologically fragile areas and environmentally sensitive areas. Based on the positioning of ecological functions in the watershed and oriented by the outstanding ecological and environmental problems, we will fully consider the integrity of the ecosystem, coordinate the systematic governance of mountains, water, forests, fields, lakes and grasses in the basin, and do a good job of water resources protection planning, water environment management planning, water ecology restoration planning and soil and water conservation planning in the watershed.

4.3 Strengthen the supervision of major environmental protection measures with great efforts

In response to various outstanding ecological and environmental problems caused by historical watershed development, develop and introduce appropriate work methods for supervision of water resources management, clarify the main objects of supervision, supervision content and supervision methods, etc., continuously improve the capacity and level of water resources supervision, so as to ensure that the development and utilization of water resources in the watershed strictly adhere to the ecological protection red line, the bottom line of environmental quality and the limit line of resource development and utilization. Thoroughly implement the environmental access list, strengthen supervision, and guarantee ecological security of the basin, achieving sustainable use of water resources.

5. Minjiang River basin water resources protection system

5.1 Scientific preparation of the Minjiang River basin comprehensive plan, highlighting its leading role

During the preparation of the Minjiang Riv-

er basin comprehensive plan, the primary goal should be to maintain its function as an important ecological protective screen in the upper reaches of the Yangtze River. Based on the functional and ecological positioning of the Minjiang River basin, the ecological space of the basin should be delineated, and “three lines and one list” should be formulated to improve the water resources protection system of the Minjiang River basin. The ecological space of Minjiang River is divided into four types: priority protection, key protection, treatment and restoration, and guided development^[14], in which the priority and key protection waters are mainly distributed in the upstream and downstream of the main stream of Minjiang River, and the water environment treatment and restoration waters are concentrated in the middle reaches of the main stream; the priority and key protection areas are mainly distributed in the upstream area of Minjiang River, and the middle and downstream areas are the key areas for economic and social development and the main agricultural products. In 2030, the attainment rate of the main control index of the water function area in the basin will reach 92% or more, and the ecological base flow control targets of 7.4 m³/s, 15 m³/s and 551 m³/s should be met at Zhenjiangguan, Jinma River outer river control gate and Gaochang cross section respectively.

5.2 Taking highlighting ecological and environmental issues as the guide, put forward the Minjiang River basin water resources protection layout

In view of the prominent environmental problems of ecological fragility in the upper reaches, water shortage and serious water pollution in the middle reaches, and high requirements for water ecological protection in the lower reaches, the layout of water resources protection in the upper, middle and lower reaches of the Minjiang River basin is proposed respectively. Upstream focus on strengthening the construction and conservation of water-containing forests, managing soil erosion, scientific scheduling, ensuring the flow of water discharge, and restoring aquatic habitats. The middle reaches should strengthen industrial structure adjustment and urban sewage treatment plant con-

struction, and strengthen pollution control of the South River, Fu River, Mangxi River and other tributaries; scientifically carry out water dispatching to guarantee the ecological water volume of the rivers; strengthen water conservation, carry out water-saving renovation of irrigation areas, and improve irrigation water utilization coefficient. Downstream focus on strengthening the water ecology protection and restoration to protect the Minjiang River system and the Jinsha River and Yangtze River system of fish migration channel. Strengthen the tributaries Dadu River and Qingyi River water conservancy project scheduling and ecological downstream water monitoring and management; strictly implement the total discharge control program for water function areas into the river.

5.3 Strengthen the ecological water security and water environment management supervision in the Minjiang River basin

During and after the implementation of the Minjiang River comprehensive plan, the main regulatory objects and contents include: ecological water security measures, soil erosion control measures and aquatic habitat restoration measures in the upper reaches; water environment management measures and ecological water security measures in the middle reaches; downstream hydropower development and channel improvement projects on the aquatic habitat disturbance control and restoration measures, etc.

6. Conclusion

The water resources protection system of the basin in the new period should be led by planning, coordinate the system management of mountains, water, forests, fields, lakes and grasses, and strengthen the supervision of major environmental protection measures.

The prominent ecological and environmental problems in the Minjiang River basin are ecological degradation in the upper reaches, short water resources and serious water pollution in the middle reaches, and damage to aquatic habitats in the basin, which are mainly caused by historical disorderly development, neglect of ecological environmental protection, and lack of environmental supervision.

The Minjiang River basin water resources protection system should first be based on the new situation and new requirements. The scientifically prepare the Minjiang River basin comprehensive planning and planning environmental assessment, so as to avoid environmentally sensitive areas from the planning level; on this basis, focus on strengthening the ecological water security measures in the upper and middle reaches, water pollution prevention measures in the middle reaches, aquatic ecological protection measures in the lower reaches and the corresponding environmental supervision.

Conflict of interest

The authors declared no conflict of interest.

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