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Original Research

Has China's River Chief System Improved the Quality of Water Environment? Take the Yellow River Basin as an Example

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Abstract

Based on the complex geographical environment of river basins and the top-down environmental management system, China has launched the characteristic river chief system. Taking the Yellow River basin as an example, this study focuses on the implementation of the river chief system in the Yellow River basin, and investigates whether the river chief system can help improve the water environmental quality in the Yellow River basin. This study collected the data of water quality categories of the river basin, main stream and main tributaries and the sections of the Yellow River basin with major pollution indicators exceeding the standard since the implementation of the river chief system in various provinces of the Yellow River basin, in order to analyze whether the river chief system has promoted the improvement of water environmental quality in the Yellow River basin, and analyzes the advantages and disadvantages of the river chief system from the aspects of the construction of the river chief system norms and institutional Settings. The study found that, firstly, the river chief system effectively improved the water environmental quality of the Yellow River basin. Secondly, the river chief system integrates the environmental power in the basin and changes the traditional fragmented management mode. Thirdly, the system of river chief has some shortcomings in the management of trans-provincial rivers and external supervision, and lacks the long-term effect of the system. Finally, this study puts forward some suggestions on how to improve the river chief system, especially how to make the river chief system more long-term.

Keywords: river chief system, Yellow River basin, water environment quality, river basin management, long-term effect

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Introduction

Water is the source of life, and the water pollution management must pay attention to the ecological environment management of the basin [1]. President Xi stressed the necessity of "lucid water and lush mountains" and a good ecological environment for human survival and development at the National Ecological Environment Protection Conference [2]. River pollution has a serious negative impact on human water security, and the "fragmentation" characteristics of many river tributaries and a wide range make it difficult to harness river basins in China. The Yellow River flows through nine provinces in China, including Qinghai, Sichuan, Gansu and Ningxia, with a total length of 5464 kilometers, spanning the east, middle and west China (Fig. 1), which is an important ecological security barrier in China. However, the Yellow River basin is ecologically fragile. Not only is there a shortage of water resources, serious soil erosion, but also serious ecological environment pollution in the basin. The water quality has been below the national average for a long time [3].

The year 2014 was the first year for China to further All-Round reform. Since then, water pollution control and other environmental protection work have been further advanced. The relevant national departments have formulated the Action Plan for Water Pollution Prevention and Control (Draft for Approval) to regulate water pollution control in key river basins. The Ministry of Environmental Protection has issued the Overall Plan for Ecological Environment Protection of Lakes with Good Water Quality (2013-2020) to protect the ecological environment of lakes with good water quality. Water quality monitoring was carried out in 968 state-controlled surface water monitoring sections (points) of major rivers and lakes in China. The main pollution indicators in the Yellow River basin were chemical oxygen demand (COD), ammonia nitrogen (NHD) and 5-day bio-chemical oxygen demand (BOD). 1.6% of the water quality sections in class I, 33.9% in class II, 24.2% in class III, 19.3% in class IV and 8.1% in class V. In major tributaries, Sushui River, as well as Sanchuan River, Fen River and Sushui River, are heavily polluted [4] (Data from the Bulletin on the State of China's Environment 2014) As the mother river of China, it is urgent to control and protect the ecological environment of the Yellow River basin.

Pollution of the river basin involves policy interaction and interest coordi-nation between the upper and lower reaches of the river basin as well as between the two sides, which is a typical cross-domain management problem [5]. For example, in the sensational "Songhua River extraordinarily large water pollution case", the Songhua River spans three provinces and regions of Inner Mongolia, Jilin and Heilongjiang, and undertakes a large amount of industrial wastewater and domestic sewage. However, due to the framework limitation of administrative power setting, the three provinces and regions only manage within their re-spective terms of reference, lacking coordination, resulting in poor water pollution control effect [6]. In terms of river basin management, China has been practicing the traditional block management model based on power setting. However, the shortcomings of the traditional management model can be clearly seen from the case of Songhua River. The phenomenon of " Too much power to participate" will be caused by the "fragmentation" management of each province. It will also cause the dilemma that many people are competing for management in the waters with rich interests and no one is interested in the waters with weak interests.

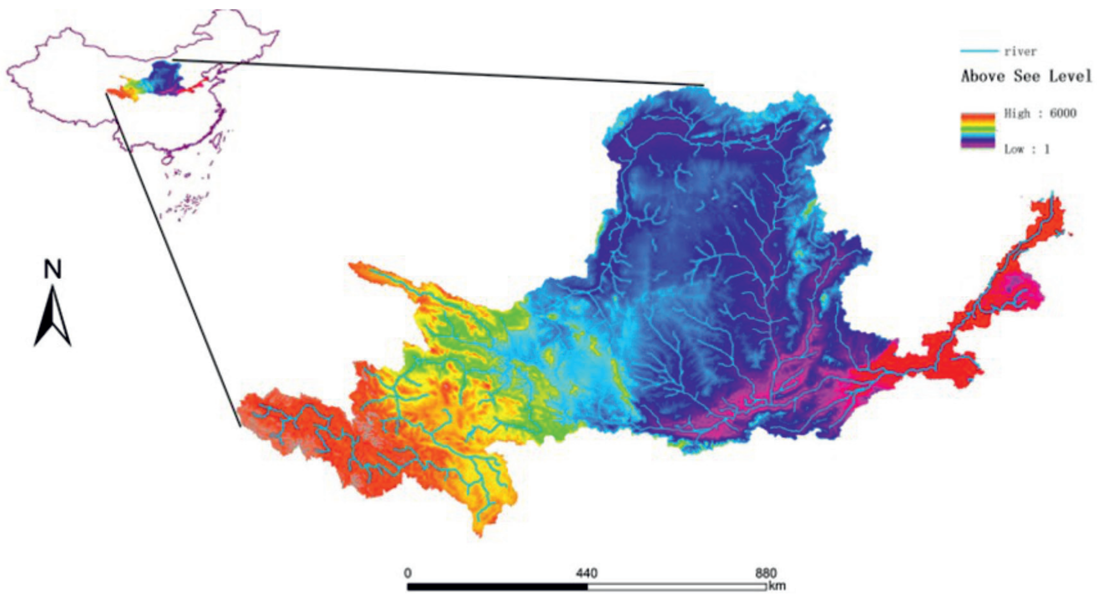

Fig. 1. Yellow River Basin.

In order to solve the problem of basin management, Changxing County of Zhejiang Province took the lead in implementing the river chief system in the country in 2003 [7]. The river chief system refers to the appointment of local leading officials as "river chiefs", who are responsible for the ecological environment management and water resources protection of specific river courses within their jurisdiction [8]. Under the leadership of the "river chief" in Chang-xing County, the ecological environment of the river channel has been significantly improved. In 2016, the General Offices of the CPC Central Committee and The State Council issued the Opinions on Comprehensively Implementing the River Chief System, requiring all parts of the country to implement the river chief system [9]. In 2017, the practice of river chief system has been carried out in all provinces, and relevant normative documents have been issued to jointly improve the ecological environment of river basins. In practice, the river chief system is often established as an organizational system with four levels of provinces, cities, counties and townships or five levels of provinces, cities, counties and villages. The river chief office is established at or above the county level to be specifically responsible for the daily work of comprehensively implementing the river chief system, and define the leading units, constituent departments and relevant responsibilities. Under the county level, there are town-ship and village river chiefs, and under the village river chiefs, there are special inspectors, special managers and cleaners. (Fig. 2) The main tasks of the river chief are: prevention and control of water pollution, management and protection of water resources, treatment of water environment, management and protection of river and lake shorelines, restoration of water ecology [10]. As the relationship between the upper and lower administrative organs in China's administrative system is that of leading and being led, river chiefs at all levels have the responsibility of leading and supervising river chiefs at lower levels beyond their own scope of work. The "river chief system" is a water environment management system with "Chinese characteristics", which conforms to the operation logic of China's administrative power and the reality of China's urgent need to solve water environment problems. It can strengthen the coordination and cooperation of administrative organs at all levels on water environment management, and make the implementation of the system more efficient. The hierarchy and responsibility division of the river chief system make the right and responsibility of river basin environmental management have a clear boundary, which can better "suit the right medicine" for the problems of the river basin, and play a good exemplary role in the management of forest ecosystems, wetland ecosystems.

The river chief system is made as an innovative system for the management of the water environment, in addition to scope complex river basin management problems effectively, can also have a positive impact on the economic development and education level of the river basin area. But the system itself is not perfect,

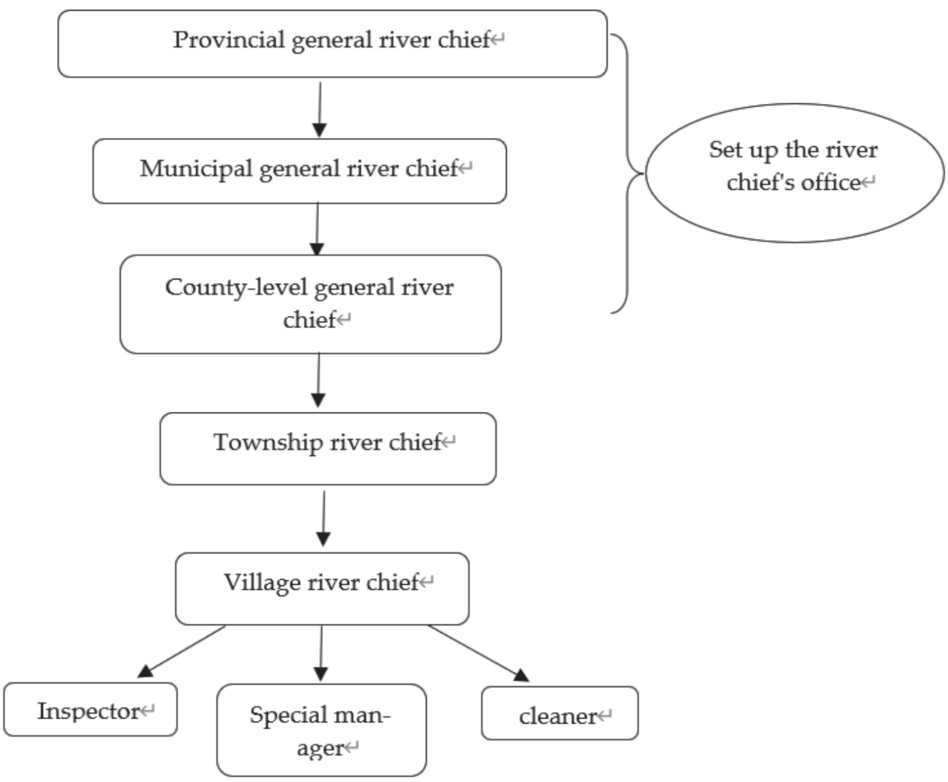

Fig. 2. Hierarchy Diagram of River Chief System Organization Structure.

not only the shortcomings within the system, there are also gaps in external supervision. Therefore, in order to maintain the superiority of the system while prolonging the effectiveness of the system, how to improve the river chief system from both internal and external aspects has become an important direction of subsequent research. As a result, the present study was done to determine the role of China's river chief system to improve the quality of water environment rendering the Yellow river basin as an example.

Materials and Methods

Data Source and Description

The overall promotion and implementation of the river chief system in China began in 2017, while the Yellow River basin flows through nine provinces, including Qinghai, Sichuan, Gansu, Henan and Shandong. The specific implementation time of each province is different (Table 1), and the river chief system was implemented as early as February 2017. For comparison, the data we collected take 2016 as the starting point and 2021 as the ending point to determine how the implementation of the river chief system affects the water quality of the Yellow River basin. First of all, in order to study the water environment quality, we collected the data of the section water quality proportion of the Yellow River basin in the National Surface Water Assessment Section (hereinafter referred to as the National Examination Section) from 2016 to 2021. These data are from the annual report on China's ecological environment published on the official website of the Ministry of Ecology and Environment (https://www.mee.gov.cn/,accessed on 2 October 2022). We analyze the water environment quality of the Yellow River basin from three parts: the Yellow River basin, the main stream and the main tributaries, based on the number of national examination sections and the proportion of water quality grades.

In addition, we collected the data of the major pollutant indicators exceeding the standard in the monitoring sections of the Yellow River basin from February 2016 to January 2021 from Ch¬ina Environmental Monitoring Station (http://www.cnemc.cn/, accessed on 3 October 2022), including the number of the five major pollutants exceeding the standard, namely, chemical oxygen demand, five-day biochemical oxygen demand, total phosphorus, ammonia nitrogen and potassium permanganate index. These basic data are used to analyze the correlation between the pollution degree of the Yellow River basin and the implementation of the river chief system.

Data Analysis Method

Statistically data were analyzed based on the qualitative or quantitative nature [11-13]. We preliminarily collected and analyzed the monitoring data of the monitoring section of the Yellow River basin. In this paper, we used the descriptive statistics method to analyze the collected data. The descriptive statistics of the national examination section data of the Yellow River basin are shown in Table 2.

The large amount of data collected, various uncertainties related to the data, and differences between values will have different significant effects on the correctness of the research results. Using traditional inferential statistics related techniques to explain these problems not only has the shortcomings of obscurity and poor readability, but also cannot simply and clearly show the data analysis and research results. Therefore, we choose to use matplotlib to draw violin chart and

Table 1. The time and normative documents for the full implementation of the river chief system in each province of the Yellow River Basin.

Province	Policy document	Release time
Shandong Province	Work Plan for Overall Implementation of River Chief System in Shandong Province	March 31, 2017
Henan Province	Work Plan for Henan Province to Fully Implement the River Chief System	May 19, 2017
Shanxi Province	Implementation Plan for Shanxi Province to Fully Implement the River Chief System	April 23, 2017
Shaanxi Province	Implementation Plan for Shaanxi Province to Fully Implement the River Chief System	February 15, 2017
Inner Mongolia Autonomous Region	Work Plan for Inner Mongolia Autonomous Region to Fully Implement the River Chief System	May 24, 2017
Ningxia Hui Autonomous Region	Work Plan for Ningxia Hui Autonomous Region to Fully Implement the River Chief System	April 19, 2017
Gansu Province	Work Plan for Overall Implementation of River Chief System in Gansu Province	July 3, 2017
Sichuan Province	Work Plan for Overall Implementation of River Chief System in Sichuan Province	May 5, 2017
Qinghai Province	Work Plan for Overall Implementation of River Chief System in Qinghai Province	May 27, 2017

*The names and dates of all policy documents in the table are all from the official websites of provincial people's.

Table 2. Statistical Description of Section Data.

	Year	Dnum	val1	val2	val3	val4	val5	val6	sum
Count	24	21	24	24	24	24	24	24	24
Mean	2017.5	96.380952	3.970833	47.55	22.15	13.745833	4.420833	8.154167	99.991667
Std	2.340568	65.927594	3.212134	21.126122	8.620501	8.725025	4.336296	8.282458	0.088055
Min	2014	26	0	19.4	0	0	0	0	99.8
25%	2015.75	31	1.6	31.725	17.8	7.4	0	0	99.9
50%	2017.5	106	3.4	45.6	23.2	15.45	3.7	6.65	100
75%	2019.25	137	6.5	56.675	27.125	19.95	7.65	14.425	100.1
Max	2021	265	14	96.8	38.5	27.8	13.9	22.2	100.1

*Year represents the year; Dumn represents the number of sections; val1-val6 represents Class I - inferior to Class V water quality; sum represents the sum; count indicates the number of water quality sections; mean is the average value of the water quality section; Std represents the standard deviation of water quality section; min represents the minimum value of water quality section; max is the maximum value of water quality section.

pie chart to analyze different problems. Violin chart is a method of drawing continuous data, which is composed of box chart and kernel density chart. It can completely and clearly show the overall distribution of data, while pie chart has obvious advantages in reflecting the data proportion.

Results and Discussion

Using the processed data and matplotlib software, a violin comparison chart of five pollution indexes is generated, which is combined in two years to show the phased characteristics of development more clearly. Violin chart combines the characteristics of box chart and density chart, and is mainly used to display the distribution shape of data. Similar to the box chart, but better at the density level. The box chart represents the average value of the data of the whole year, and the yellow line refers to the average value.

The five-day biochemical oxygen demand expressed in the form of BOD5, refers to the dissolved oxygen consumed in the biochemical process of microbial decomposition of organic matters in water under specified conditions [14]. If the concentration of BOD5 is too high, the monitored sections of the Yellow River basin will exceed the standard. The more sections exceed the standard, the deeper the water pollution is. According to the analysis of the BOD5 (Fig. 3) over standard sections in 6 years, the results show that the

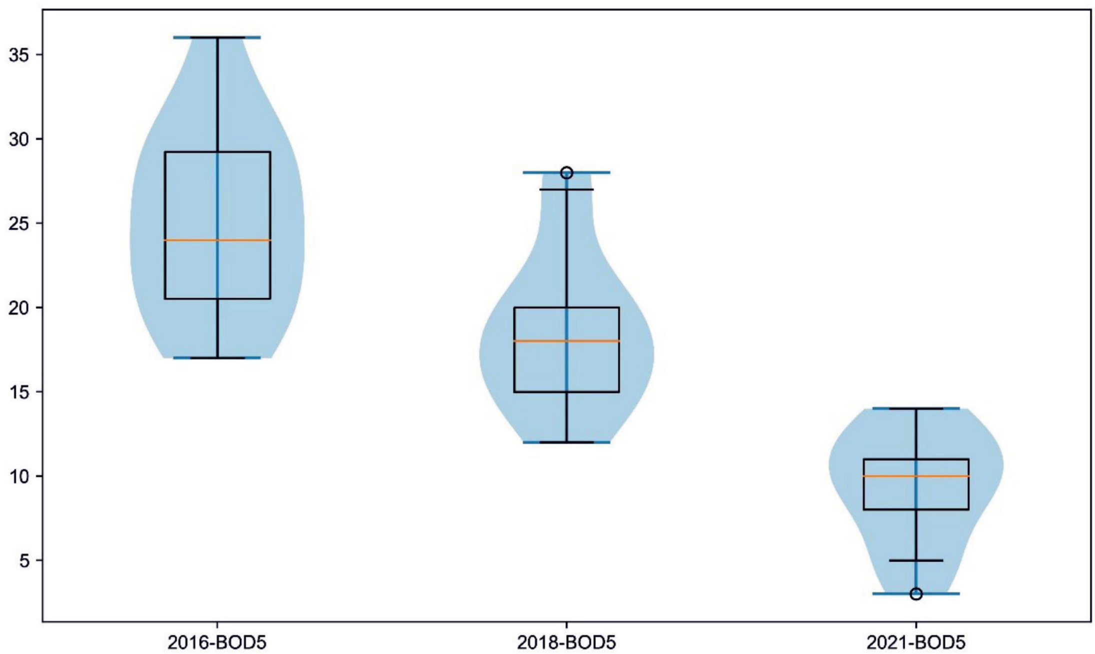

Fig. 3. Comparison of BOD5 Exceedance Sections in 2016-2021.

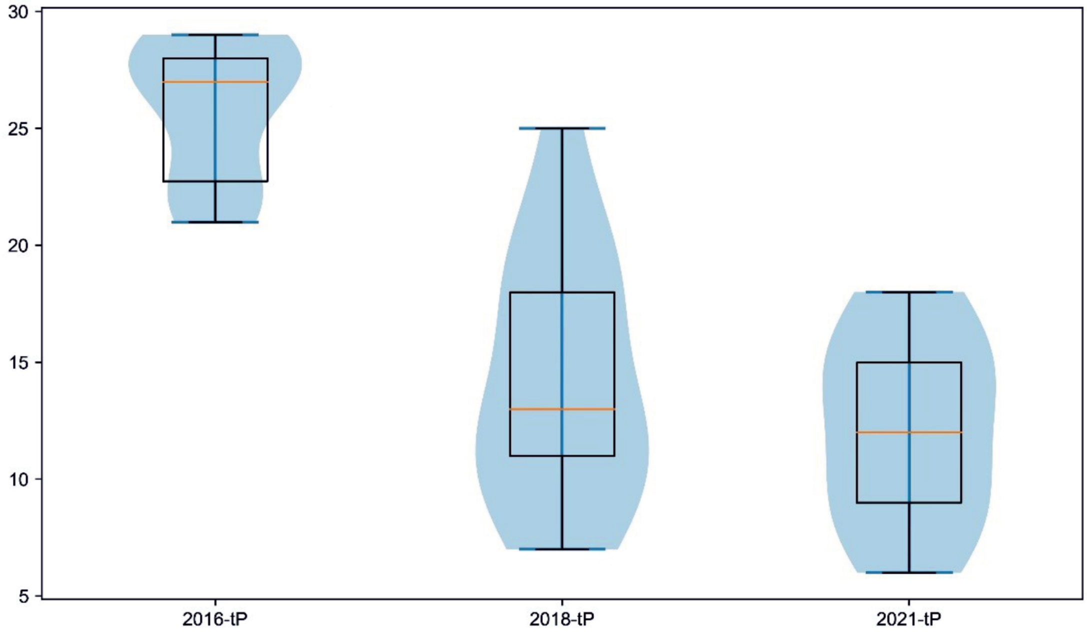

Fig. 4. Comparison of TP Exceedance Sections in 2016-2021.

sections with BOD5 over standard concentrations show a decreasing trend year by year, which proves that the water quality is improving year by year.

Total phosphorus (TP) is the sum of various forms of phosphorus in water bodies, mainly from domestic sewage, chemical fertilizers, organic phosphorus pesticides. Excessive phosphorus will cause water pollution and odor, and eutrophication of lakes. According to the 6-year TP analysis (Fig. 4), the results show that: the section of the Yellow River basin with total phosphorus exceeding the standard shows a decreasing trend, especially from 2016 to 2018. The total phosphorus content in the overall water area tends to the standard, and the water quality gradually improves.

Chemical oxygen demand (COD) is an important indicator of organic pollution in water bodies. The higher the COD value, the more seriously the water body is polluted by organic substances. The more the number of sections with COD exceeding the standard, the more serious the water pollution in the Yellow River basin. According to the violin chart results of COD (Fig. 5) from 2016 to 2021, the sections with

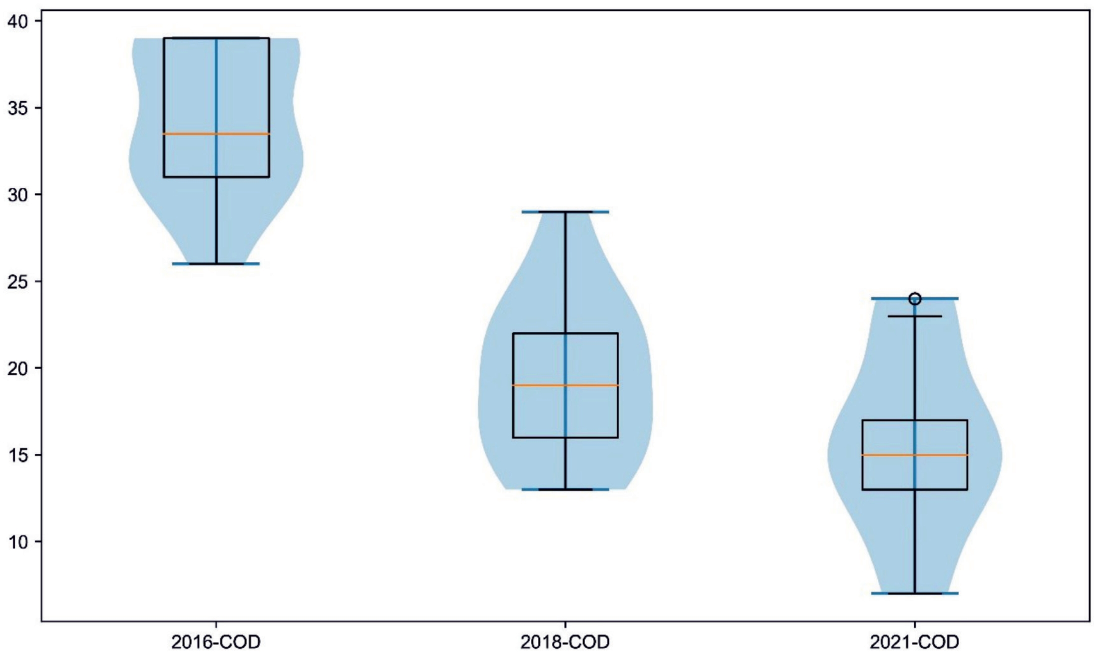

Fig. 5. Comparison of COD Exceedance Sections in 2016-2021.

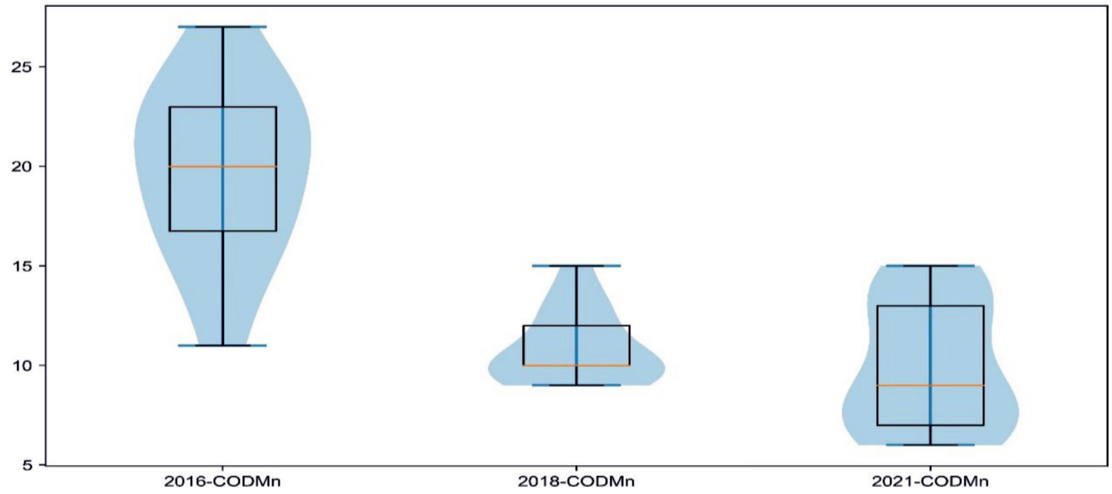

Fig. 6. Comparison of CODMn Exceedance Sections in 2016-2021.

excessive COD showed a decreasing trend. Compared with 2016, the sections with excessive COD in 2018 decreased significantly, indicating that the water pollution in the Yellow River basin was significantly reduced.

The chemical oxygen demand measured with potassium permanganate as oxidant is called potassium permanganate index (CODMn) or oxygen consumption, which is an index for evaluating and monitoring the organic content of surface water or drinking water such as seawater, rivers, lakes. According to the analysis of the CODMn (Fig. 6) exceeding standard section data of the Yellow River basin in the past six years, the results show that the number of exceeding standard sections has a decreasing trend. At the lowest point in 2021, the decrease will reach more than 50%, indicating that the content of exceeding standard organic matter in the water body of the Yellow River basin is decreasing year by year.

Ammonia nitrogen (NH_3) is the main oxygen consuming pollutant in the water body. If it exceeds the standard, water eutrophication may occur. The more sections with NH3 exceeding the standard, the more serious the water pollution caused by the main oxygen consuming pollutants. The violin chart of NH_3 from 2016 to 2022 (Fig. 7) shows that the number of sections with NH3 exceeding the standard is decreasing year by year, indicating that the water pollution caused by major oxygen consuming pollutants in the Yellow River basin is improving year by year.

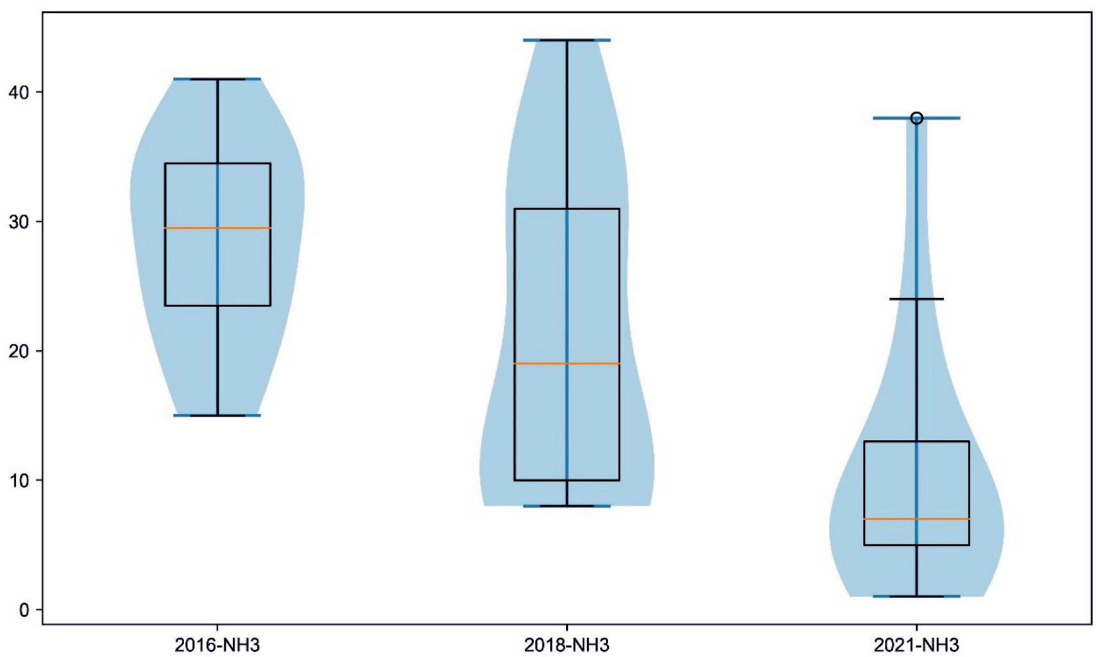

Fig. 7. Comparison of NH3 Exceedance Sections from 2016 to 2021.

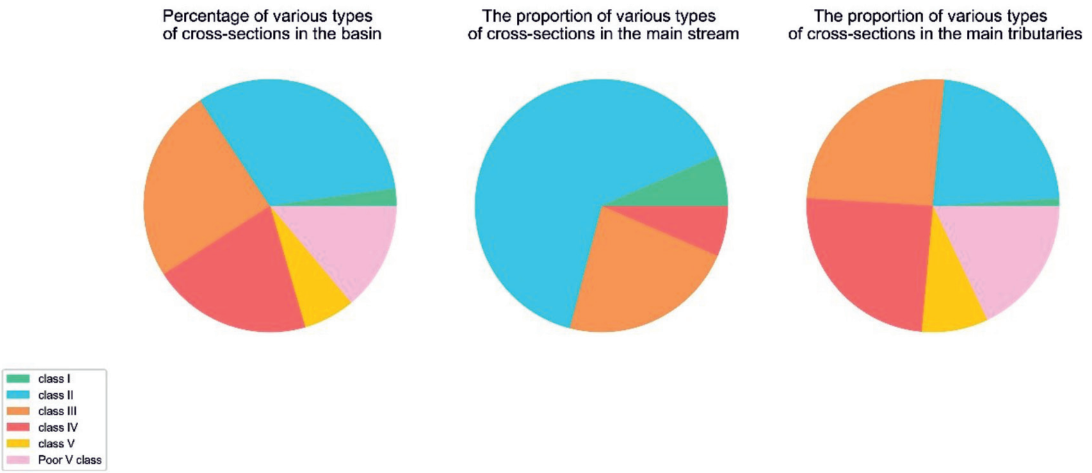

Fig. 8. Proportion of Water Quality of Various Sections in the Yellow River Basin in 2016.

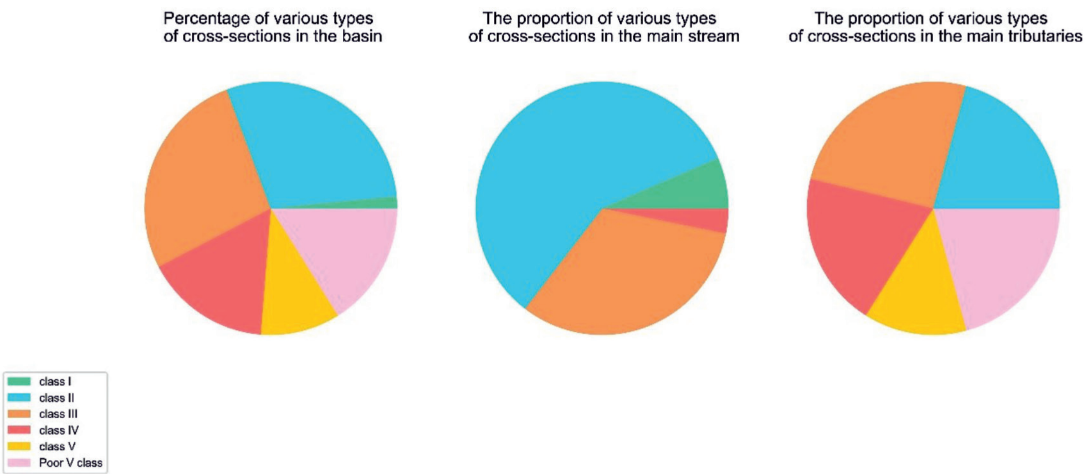

Fig. 9. Proportion of Water Quality of Various Sections in the Yellow River Basin in 2017.

At the same time, the water quality categories of various sections in the yellow river basin were processed by using matplotlib software to generate pie charts.

In 2017 (Fig. 9), it is the node for all provinces in the Yellow River basin to start implementing the river head system. From the pie chart analysis of the water quality proportion of the Yellow River basin in the three years from 2016 (Fig. 8) to 2018, it can be seen that in the section of the basin, the water quality category in 2017 has not improved compared with 2016.

Table 3 shows the standard values of each classes of pollution indicators. In the main stream section, the water quality of Class II is mainly, nearly 60%. There is no section of Class V or below. The water quality of Class IV decreases, while the water quality of Class III increases, but the water quality of Class II decreases, basically unchanged. In the main tributary sections, the proportion of Class I-III water quality decreased, while Class IV-inferior to Class V water quality increased, and the water body deteriorated slightly. In 2018 (Fig. 10),

Table 3. Standard value for each class of the pollution indicators.

Classification		Standard values (mg/L)					
		Class I	Class II	Class III	Class IV	Class V	Poor V class
Pollution indicators	TP	≤ 0.02	≤ 0.1	≤ 0.2	≤0.3	≤ 0.4	≥0.4
	COD	≤ 15	≤ 15	≤ 20	≤ 30	≤ 40	≥ 40
	NH3	≤ 0.15	≤ 0.5	≤ 1.0	≤ 1.5	≤ 2.0	≥ 2.0

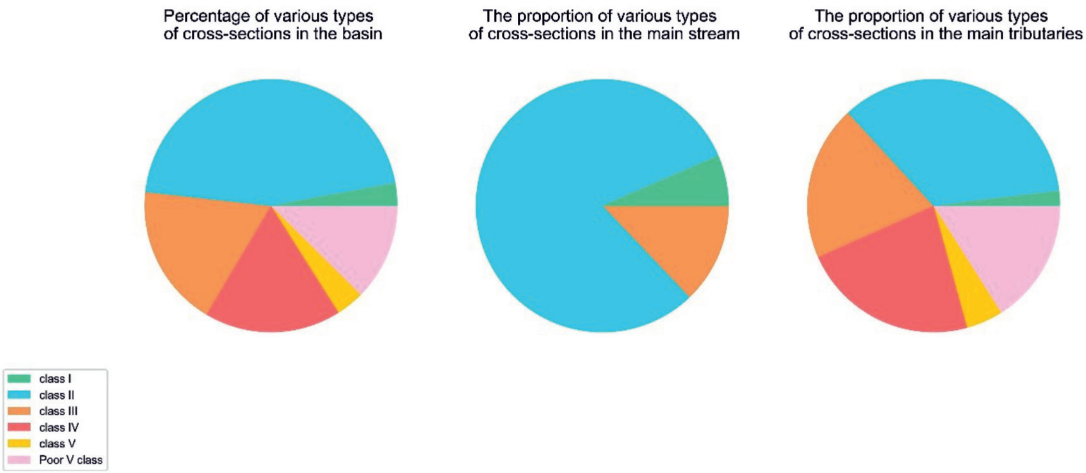

Fig. 10. Proportion of Water Quality of Various Sections in the Yellow River Basin in 2018.

compared with 2017, the proportion of Class I-III water quality in the river basin section increased, while the proportion of Class V and worse than Class V water quality decreased, and the water quality increased relatively. In the main stream section, Class II water quality accounts for more than 80%, Class I water quality is basically flat, Class III water quality decreases, Class IV water quality disappears, and the water quality is significantly improved. In the sections of main tributaries, Class I water quality appears. The proportion of Class I-III water quality increases, while the proportion of Class IV water quality remains the same, while the proportion of Class V and inferior to Class V water quality decreases relatively, and the overall water quality has improved significantly.

The water quality of the Yellow River basin in recent years after the implementation of the river chief system is shown in the figure. In 2019 (Fig. 11), Class II water quality sections accounted for about 50% of the river basin sections. Compared with 2018, the proportion of Class IV-inferior to Class V water quality decreased, but the decline was small, and the overall water quality improved slightly. In the main stream section, there is no section of Class IV or below, the proportion of Class I-III water quality is the same, and the water quality has no obvious change. In the main tributary sections, the proportion of Class I-III water quality increased, of which the proportion of Class II water quality increased significantly, while the proportion of Class IV-inferior to Class V water quality decreased significantly, of which the proportion of inferior to Class V water quality decreased relatively, and the overall water quality improved relatively.

In the section of the basin, the proportion of Class I-III water quality in 2020 is significantly higher than that in 2019. The water quality inferior to Class V disappears, Class V water quality is significantly reduced, Class IV water quality is basically flat, and the water quality is relatively improved. In the main stream section, Class III water quality disappeared, Class I water quality decreased slightly, but the proportion of Class II water quality increased, and the overall water

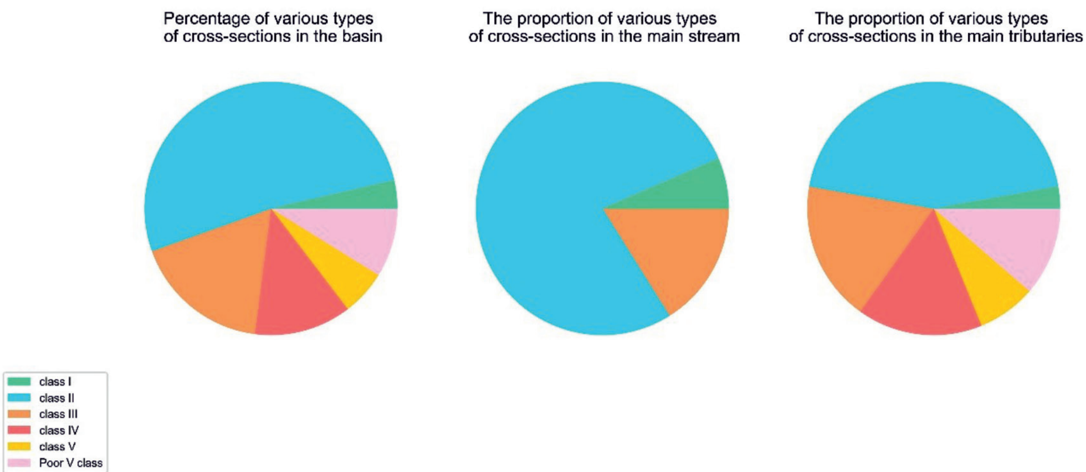

Fig. 11. Proportion of water quality of various sections in the Yellow River basin in 2019.

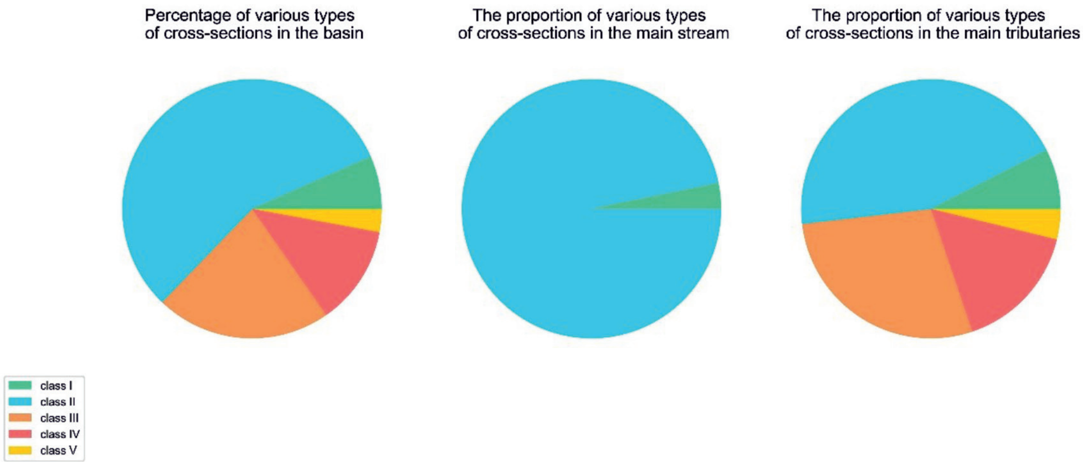

Fig. 12. Proportion of water quality of various sections in the Yellow River basin in 2020.

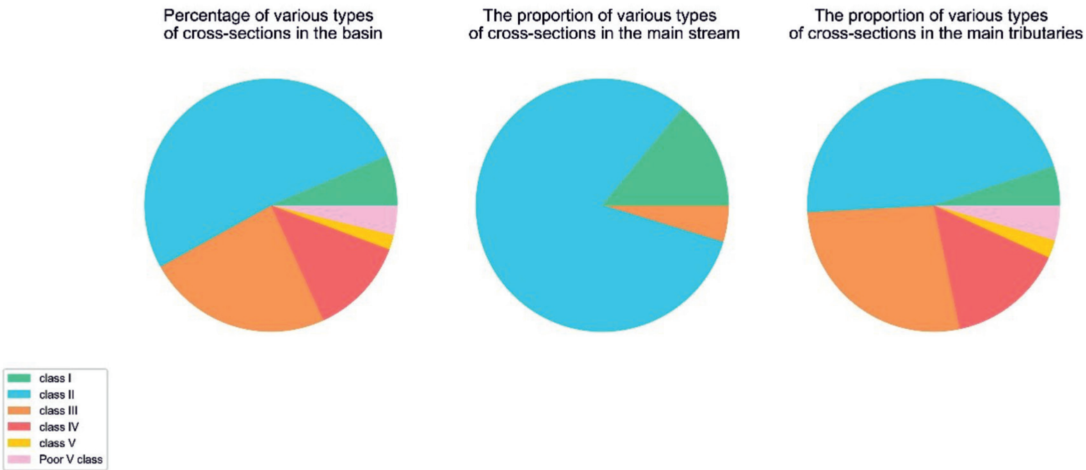

Fig. 13. Proportion of Water Quality of Various Sections in the Yellow River Basin in 2021.

quality improved significantly. In the main tributary sections, the proportion of Class I-III water quality increased significantly, the inferior Class V water quality disappeared, the Class V water quality decreased significantly, the Class IV water quality was basically flat, and the water quality improved significantly.

It can be seen from the comparison between 2021 (Fig. 13) and 2020 (Fig. 12) that the proportion of Class I-III water quality in the watershed section is basically in a flat state. Although there is a small proportion of water quality inferior to Class V, the proportion of Class V water quality decreases correspondingly, and is basically in a flat state. In the main stream section, a small number of Class III water quality sections appear, but the proportion of Class I water quality increases significantly, and the water quality is relatively improved. In the main tributary sections, the overall proportion of Class I-III water quality is basically the same, with a smaller proportion inferior to Class V water quality, but the proportion of Class V water quality is correspondingly reduced, and the overall situation is flatFrom the above analysis, it can be seen that after 2017, the sections of the Yellow River basin with major pollution indicators exceeding the standard are declining, reflecting the improvement of water environment quality in the Yellow River basin. During 2016-2017, the overall water quality of the Yellow River basin was slightly polluted. From the data from 2018 to 2021, it can be seen that the water quality of the Yellow River basin has improved significantly, and the overall water quality is in good condition.

Through the analysis of the above data, we come to the conclusion that the implementation of the river chief system has played a significant positive role in improving the water environment quality of the Yellow River basin. As a system for harnessing complex water environment, the river leader system has achieved remarkable results in the short term, but it is found that the river leader system has natural drawbacks after investigating its institutional roots. First, the implementation of the river chief system relies too much on "rule by man", which will bring great instability to the implementation effect of the system; Second, the river chief system is a water environment management system created based on the inadequacy of the bureaucratic environmental management system, which has obvious problem response characteristics. Although it is effective, it is not perfect; Third, the river chief system pays too much attention to internal assessment in terms of system effectiveness assessment, neglects the external supervision mechanism, and is difficult to form a long-term mechanism.

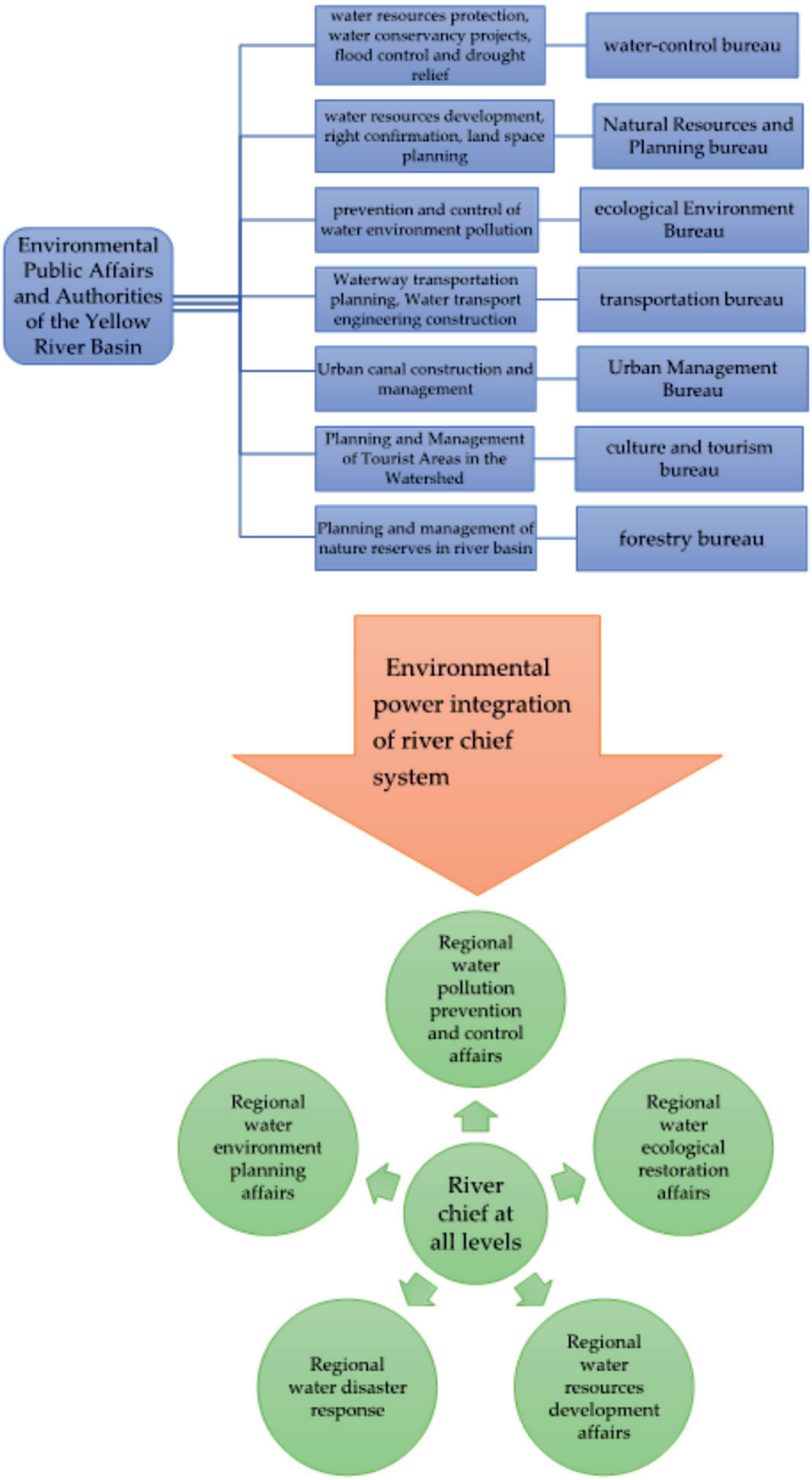

Fig. 14. Schematic diagram of integration of river head system on environmental public power in the basin. The content of "Environmental Public Affairs and its Authorities in the Yellow River Basin" takes the institutional functions of Zhengzhou Municipal People's Management as an example, source: Zhengzhou Municipal People's Government.

The river chief system refers to the responsibility for organizing, leading and coordinating all relevant functional departments by the party committees and chief executives at all levels to serve as the "river chiefs" of the main river and lake basins in their respective jurisdictions at different levels [15]. The core of the river chief system is "river chief", and river chiefs at all levels are the greatest features of this system [16]. However, the appointment of local party and government leaders at all levels in a region is not unchanging, and they may experience job changes such as promotion, demotion and transfer. The management responsibility of "river chiefs" for the basin is not "lifelong responsibility system". The identity of river chiefs will change with the transfer of positions. Different "river chiefs" will have different management directions and specific measures. The consequences of this "difference" are not absolutely positive. The uncertainty caused by the dependence on local party and government leaders at all levels will have a great negative impact on the implementation of the river chief system.

The bureaucratic theory (also known as rational bureaucracy) proposed by the German sociologist Marx Weber [17] explains the distribution of administrative power: in the power system structure of administrative organizations, distributing class of administrative power is according to the rectangular relationship of the hierarchical system. Vertical view presents a top-down "command-obedience" relationship, and horizontal view presents a "cooperation-cooperation" between independent powers [15]. China's environmental management system is still essentially the operation of this "bureaucracy" power. In this mode, the environmental public affairs related to the basin cannot be undertaken by a single administrative body. Taking the Yellow River Basin as an example, it spans totally nine provinces, each province has different jurisdictions, and the provincial river chief system bear the management responsibility for water environment public affairs for sections of the Yellow River Basin in their respective jurisdictions. From the government interior perspective, the departments related to the Yellow River Basin include environmental protection departments, the ministry of water resources, transportation sectors, forest departments (Fig. 14) [18] and these departments undertake the supervision and management o-f ecological environmental protection, natural resources exploitation and utilization in the Yellow River Basin within their respective terms of authorities, thus forming the well-known situation of" Too much power to participate".

In the face of complex and serious water environment problems, river basin management should start from the concept of integrated ecosystem and implement the comprehensive adjustment mechanism of river basin management [19]. The river management system has concentrated the power and responsibility of this fragmented management model and set up a "master leader". The authority of relevant departments in the water environment management of the basin was integrated to achieve unified and coordinated management of environmental public affairs in the basin, and the chaos of " Too much power to participate "was eliminated. However, the river chief system is limited to the power integration between the horizontal administrative departments below the provincial level, which is of great benefit to the management of environmental public affairs in the river basin with the province as the unit. However, for the rivers across provinces such as the Yellow River basin, how to coordinate the environmental power among provinces has not been resolved, which leads to the different

Table 4. The examinees of river chief system in various provinces of the Yellow River basin.

Province	Normative documents	The examinee
Qinghai Province	Regulations of Qinghai Province on the Implementation of the River Chief System and the Lake Chief System (2021)	General river chief and lake chief above county level
Gansu Province	Work Plan for Overall Implementation of River Chief System in Gansu Province (2022)	River chief above county level
Sichuan Province	Regulations of Sichuan Province on the Chief System of Rivers and Lakes (2021)	Local people's governments above the county level
Ningxia Hui Autonomous Region	Ningxia Hui Autonomous Region's Work Plan for Comprehensively Implementing the River Chief System (2017)	River chief above county level
Inner Mongolia Autonomous Region	Inner Mongolia Autonomous Region's Work Plan for Comprehensively Implementing the River Chief System (2017)	River chief above county level
Shaanxi Province	Shaanxi Province comprehensively implements the River Chief System (2017)	River chief and lake chief above county level
Shanxi Province	Shanxi Province comprehensively implements the River Chief System (2017)	Superior river chiefs
Henan Province	Henan Province's Work Plan for Comprehensively Implementing the River Chief System (2017)	Provincial River Chief System Office
Shandong Province	Shandong Province's Work Plan for Fully Implementing the River Chief System (2017)	River chief above county level

governance effects of the water environment of the rivers across provinces in different provinces.

The exercise of power requires supervision. The river chief system is a "centralized" system that integrates and concentrates the environmental power in the river basin. It needs more all-round supervision to ensure the effective implementation of the system and prevent the abuse of power. However, through the study of the normative documents of the river chief system in the provinces of the Yellow River basin, it can be found that in the assessment accountability system of the river chief system, no matter the water quality standards, assessment standards or assessment items, they are all set by the administrative organs themselves. The examinee is mostly the superior "river chiefs". [20] essentially belongs to the internal assessment of the authority (Table 4), and external supervision is seriously ignored. Without external supervision, the fairness of the system cannot be guaranteed.

It can be seen from the table that the examinee of the river chief system stipulated in the normative documents of nine provinces in the Yellow River basin is mostly river leaders at or above the county level. In addition, there are people's governments and river chief system offices. In essence, it is an assessment mechanism focusing on self-supervision, self-assessment and self-accountability, lacking external constraints from the public and other authorities.

This study was limited to the absence of assess the status of several rivers as a comprehensive study. Additionally, lack of the evaluation of all factors related to the environmental evaluation of the water quality is another important limitation. However, using standard statistical evaluation and also traditional inferential statistics related techniques to ex-plain, facilitate the scientific interpretation and inference of data. Furthermore, assessment of the status of yellow river as one of the biggest rivers in China was the most important strenghtpoint of the study.

Conclusions

In this study, we collected the water quality categories before and after the implementation of the river chief system in the Yellow River basin, and the data of the sections where major pollutants exceeded the standard, analyzing the data by matplotlib software to test the impact of the implementation of the river chief system on the water environment of the Yellow River Basin. The results lead us to the following conclusions: First, the implementation of the river chief system has really improved the quality of the water environment in the Yellow River Basin to a certain extent. Through the analysis of water quality categories and over-standard cross sections of the main pollutants, it can be seen that the proportion of water quality in class I-III has increased significantly compared with before the implementation of the river chief system, the proportion of inferior class V water quality is also decreasing, and the water quality of the Yellow River Basin, main stream and main tributaries has been significantly improved. The over-standard cross sections of the main pollutants generally show a decreasing trend year by year, and the overall water environment of the Yellow River Basin has been significantly improved. Second, the river chief system is highly in reliance on "rule of man", it is difficult to get rid of the instability caused by the job transfer of river chiefs. In the face of such problems, taking the way of setting up a "lifelong responsibility system" for river chiefs can ensure the stability of policy implementation. Third, through the research of the operation mode of the river chief system and the environmental management system of China's bureaucratic system, it is found that the river chief system can effectively integrate the environmental power of various departments below the provincial level. But in dealing with such cross-provincial basin problems in the Yellow River Basin, it has not yet crossed the conflict of environmental power between provinces, and a more better power integration mode is needed. Finally, working through the examinee of the river chief system and finding that it is essentially the internal assessment of administrative organs, introducing other external supervision mechanisms such as the public and the procuratorate can ensure the fairness and authenticity of the implementation of the system. Although river chief system in China is quite effective, it is still necessary to actively summarize the problems existing in the implementation and continuously improve the system so that the river chief system can become a long-term mechanism for dealing with complex river basin problems. This study focuses on the effect of the river chief system implementation from the perspective of water quality improvement in the Yellow River Basin, whether at the level of data collection and research, it is not possible to deeply analyze the overall situation of the river chief system, the research angle is not comprehensive enough, and the research on the river chief system stays on the theoretical exploration. In the following research, we will start from the actual situation of the river chief system in various provinces, pay more attention to the specific methods and strategies of system implementation, combining theory and practice and provide more practical suggestions for the good development of the river chief system.

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Conflict of Interest

The authors declare no conflict of interest.

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