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Original Research Paper

Water Pollution and Relevant Preventive Measures in the Hechuan Segment of Fujiang River

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ABSTRACT

Dissolved oxygen (DO), NH_4^+-N, total phosphorus (TP), COD_{Mn} and BOD_5 in water in the Hechuan segment of Fujing River were monitored to assess water pollution in the river scientifically. Water pollution indexes were analysed and their pollution load-sharing ratios were calculated by using single pollution index method and Nemerow comprehensive pollution index method, respectively. Results show that the water quality in 25% of the monitored sections can be considered clean and the water quality of 75% of the sections can be considered slightly polluted in two water functional zones in the Hechuan segment of Fujiang River with water quality control targets of Level III and Level IV, respectively. Water quality declines from upstream to downstream. DO does not exceed standards in all the sections. NH_4^+-N significantly contributes to water pollution in all the sections; as a consequence, NH_4^+-N is a major pollution index in the entire Fujiang River. In some sections, TP, COD_{Mn} and BOD_5 yield high pollution load sharing ratios. The distribution of the main pollution sources of different sections shows that the pollution indexes exceeding standards are mainly influenced by various pollution factors, such as cultivation, industrial wastewater, urban and rural domestic sewage, and agricultural non-point sources. Therefore, relevant preventive measures and recommendations are provided as a reference of the comprehensive control of water pollution in the Hechuan segment of Fujiang River.

INTRODUCTION

In the junction of Zhong hill and Pingxingling valley in Chongqing China, the Hechuan district of Chongqing is located in the upper reaches of Yangtze River. The entire area of the district is 2356.21 km^2, of the total area, 49.97% covers farmlands. Agriculture plays a major role in national economic development. Near river, leisure agriculture and tourism have developed rapidly. Therefore, the number of tourists or tourism value has increased significantly in some cultural attractions, including Fishing Town, Laitan Old Town and Wenfeng Old Street. Moreover, tourism may become a leading industry. With advances in land development and utilization, human activities highly influence water quality. As a consequence, severe water environment problems have exacerbated within the region. Thus, water pollution and relevant preventive measures in Fujiang River should be investigated.

In the Hechuan segment of Fujiang River, water flows from Xiamaliu village in Biekou township, Tongnan County in Chongqing to Jialing River via Yazui in Hechuan. The total length of the segment is 66.73 km with drops of 35.66 m and an average gradient of 0.56%. The drainage area is 458.98 km^2, and the segment spans 19 rivers and streams. Hechuan segment is in a subtropical humid climate zone with an annual mean temperature of 18.2°C and an annual average precipitation of 1107.1 mm. The precipitation in July, August and September reaches 74% of the total annual precipitation. The annual average flow in Xiaoheba Hydrometric Station is 461 m^3/s. The average flow in the main flood seasons from July to September is 1083 m^3/s (Wang et al. 2014, Wang et al. 2012). The region is characterized by mild climate, high humidity, abundant rainfall, and long frost-free season. However, the region shows several disadvantages, such as high land reclamation rate, low forest coverage rate, and severe water and soil loss. The water quality of Hechuan segment is poor because of domestic sewage and industrial wastewater from towns along the river. As such, the scientific assessment of water pollution and prevention has been prioritized by the government for comprehensive control and planning in Fujiang River.

Studies on the water environment of Fujiang River are limited, relevant research has mainly focused on the water environmental capacity of Mianyang segment and Suining segment (Yang et al. 2007, Shen 2007, Xiong et al. 2008). Dai et al. (2008) examined the water environmental capacity of Anchang River, a branch of Fujiang River, to determine water pollution in the branches of Fujiang River, and revealed that wastewater discharged to Anchang River is mainly composed of industrial wastewater and domestic sewage from pollution-discharging points along Anchang River. Furthermore, the actual pollution load does not exceed the pollutant carrying capacity of this river (Dai et al. 2008).

Li et al. (2010) analysed the water environmental capacity of Jianjiang River, another branch of Fujiang River, and suggested that industrial wastewater and domestic sewage play important roles in Jianjiang River. The main specific pollutants, namely, COD and NH_4^+-N, exceed relevant standards, but the water environmental capacity of Jianjiang River is unsaturated (Li et al. 2010). Xiao (1984) investigated the water quality of Fujiang River to assess water pollution and to promote preventive measures in Suining Segment of Fujiang River, and found that most sections are polluted to different levels. He et al. (2005) conducted a fuzzy assessment of the water quality of Fujiang River, and found that the water quality in most sections is at Level III and the water quality in other sections is at Level I or Level II. Shu & Zhang (2013) considered that the total nitrogen in the Suining segment exceeds standards; the water quality in boundary sections also reaches Level III of surface water. Yu (2006) investigated the pollution sources in Fujiang River and the influence of boat cage cultures in ship hulls on the water quality in Hechuan segment and found that the concentrations of NH_4^+-N, TP and COD_{Mn} are remarkably affected by this activity.

Zhang (2012) conducted a simulation study on influence on concentration by constructing Qingyi-Fujiang Grand Bridge and considered that less than 1 km is influenced by the Cofferdam Construction Scheme, the protective zone of drinking water source is not influenced. Csathò et al. (2007) considered that a non-point source is the main source of water pollutants, including agricultural non-point source, which is the largest contributor, because the industrial point source pollution is controlled. Li (2007) conducted a simulation assessment of non-point source pollution in Jialing River basin and revealed that the middle and lower reaches of Fujiang River experience severe losses of non-point-source nitrogen and phosphorus; the middle and lower reaches contribute approximately 30% of pollution load to Jialing River basin.

Ding et al. (2012) examined the spatial distribution of agricultural non-point source pollution and identified the pollution sources in Fujiang River basin and found that the loss of chemical fertilizers in agricultural lands is the primary pollution source (62.12%). The loss of chemical fertilizers in dry land is the most severe and thus contributes 50.49% of pollutants (Ding et al. 2012). Water pollution and preventive measures in the Hechuan segment of Fujiang River have yet to be explored.

River water pollution has been extensively investigated. In space, water pollution in different rivers or in different branches and sections of the same river varies significantly. In time, pollution varies in the same river in different periods of the year. The main pollution indexes of water quality can be remarkably influenced by pollution sources. River water pollution is assessed on the basis of measured data. The prevention of river water pollution may be analysed and discussed in terms of the pollution load sharing ratio of pollutants and categories, quantity, scale and distribution of pollution sources. Relevant preventive measures may be proposed by considering these factors.

This study examines the Hechuan segment of Fujiang River. Several points in the area were selected to monitor the main water quality indexes, current situation of water quality and factors that influence water pollution were analysed, preventive measures were proposed, and recommendations were provided as a reference for water pollution control in Hechuan District.

MATERIALS AND METHODS

Arrangement of point locations in the monitored sections: According to 2010 Chongqing Water Functional Zoning Revision Report (Chongqing Municipal Water Conservancy Bureau 2010), the Hechuan segment is divided into two functional zones: (1) reservation area and (2) development and utilization area. The former spans the entrance in Tongnan County and Lianghekou village in Weituo town, Hechuan district. The entire length is approximately 70 km, with a low degree of water source development and utilization. In addition, the water control target is Level III. The latter covers Lianghekou village and river mouth with a total length of approximately 15 km, the latter is located in the main urban area of Hechuan district, with residential and industrial areas distributed along the river. The water control target is Level IV.

Eight water quality-monitoring sections with four sections in each functional zone were selected on the basis of the actual division of water functional zones in the Hechuan Segment (Table 1).

Monitoring indexes: The monitoring indexes of water quality in the Hechuan segment of Fujiang River include dissolved oxygen (DO), NH_4^+-N, total phosphorus (TP), COD_{Mn} and BOD_5. These indexes are sampled twice a day and then averaged.

Table 1: Distribution of the water quality monitoring sections.

	Number	Position	Pollution Source	Remark
Level III functional zone	1	100 m from the upper reaches of Dinosaur Lake Resort in Jinsha Village	Villages in the upper reaches, farmlands, and scatter-fed livestock and poultry	Entrance section
	2	Right across the corner of Xiaxin Street and Yushizhi Street	Blocks, cultivated land, and beer brewery; riverway has been managed.	Control section
	3	50 m from the lower reaches of China Mobile Service Hall in Gaolou Village	Cultivated land and villages; the degree of control is low.	Control section
	4	200 m from the lower reaches of junction of Fujiang and its branch Qiongjiang	Qiongjiang River in the upper reaches flows into the area and village; the degree of control is low.	Control section
Level IV functional zone	5	500 m from the upper reaches of Feijiadu	Villages and cultivated land; the degree of control is low.	Control section
	6	Junction of Yandong Bay and Guanyin Rock	Salt chemical plant, electroplate factory, heat treatment plant, and steel mill	Control section
	7	Teachers' Community in the lower reaches of Fujiang Sanqiao	Boat cage culture, pollution discharge by urban residents, and a small number of restaurants in boats	Control section
	8	250 m from lower reaches of Fujiang Yiqiao and 200 m from the upper reaches of confluence of Jialing River	Restaurants in Wenfeng Old Street and wastewater from domestic sewage treatment plant	River mouth section

Monitoring methods: U-52 HORIBA multi-parameter water quality analyser was used to measure DO in water at the site. The samples were obtained, stored and sent to our laboratory and examined. In water sampling, left, middle, and right vertical lines were set in the river section as replicates. At a water depth of more than 2 m, composite samples were obtained, i.e., the samples were collected at 0.5 m underwater, in the middle and 0.5 m above the bottom, respectively; these samples were then mixed. At a water depth of more than 1 m but less than 2 m, the samples were collected 0.5 m underwater and 0.5 m above the bottom. These samples were then mixed. At a water depth of less than 1 m, the samples were collected in the middle part of water.

NH_4^+-N in the collected water samples flow was determined using a Skalar flow analyser. TP was quantified in accordance with Water and Wastewater Monitoring Analysis Methods (State Environmental Protection Administration, 2002). COD_{Mn} was measured through permanganate titration. BOD_5 was determined by dilution and seeding method (China Environmental Protection Department 2009).

Sampling time and assessment standard: Water quality was monitored twice in all of the monitoring sections in the Hechuan segment of Fujiang River in June 2013. The average value was also obtained during analysis. In addition, Environmental Quality Standard for Surface Water was used as the main basis for analysis (China Environmental Protection Department 2009). The water sample was considered unqualified if any one index exceeds standards. If the water indexes in more than 1/2 monitoring points were inferior to Level V quality, the entire region would be estimated as poor Level V. Specific standards of classification and limit values are given in Table 2.

RESULTS AND ANALYSIS

Assessment Index of the Water Quality in Fujiang River

Currently, single factor analysis method is a common and mature method, and has a highly instructive function during environmental control (Li et al. 2012). The Nemerow comprehensive pollution index method (Nemerow 1974) increases the consideration of weight factors, and can highlight the influence and function of pollutants with biggest pollution indexes to the environmental quality. Thus, this method is a frequently used method worldwide to calculate. Single factor analysis method and Nemerow comprehensive pollution index method (Nemerow 1974, Hao et al. 2008, Li et al. 2010, Wang et al. 2008) were performed to assess five indexes to accurately evaluate the pollution of the Hechuan segment in Fujiang River. The two methods are expressed as Equations (1) and (2).

$$P_i = \frac{C_i}{S_i} \qquad ...(1)$$

$$P_w = \sqrt{\frac{(MaxP_i)^2 + (AveP_i)^2}{2}} \qquad ...(2)$$

Table 2: Standard limit values of the surface water environmental quality indexes monitored; unit: mg/L.

	Category		Level I	Level II	Level III	Level IV	Level V
1	Dissolve oxygen	≥	7.5	6	5	3	2
2	NH_4^+-N	≤	0.15	0.5	1	1.5	2
3	Total phosphorus	≤	0.02	0.1	0.2	0.3	0.4
4	Permanganate	≤	2	4	6	10	15
5	Five-day BOD	≤	3	3	4	6	10

Table 3: Division standard of pollution levels for comprehensive polluted water quality index.

P_w	<1	1~2	2~3	3~5	>5
Water quality level	Clean	Slightly polluted	Polluted	Heavily polluted	Severely polluted

Where, P_i is the single factor pollution index of i^{th} pollutant; C_i is the actual average measured value of i^{th} pollutant, mg/L. S_i is the assessment standard value of i^{th} pollutant, mg/L. P_W is the comprehensive pollution index. The single factor pollution index of DO is the reciprocal of Eq. (1).

Five pollution levels are divided according to comprehensive pollution index, as given in Table 3.

Comprehensive assessment for all sections is conducted based on division standards in Table 3. Relevant results are provided in Table 4.

These five pollution indexes are considered as pollution factors, and the pollution load sharing ratio of different indexes are calculated using Eq. (3). Table 5 shows further details.

$$K_i = \frac{P_i}{\sum_{i=1}^{n} P_i} \times 100\% \quad ...(3)$$

Where, K_i is the pollution sharing ratio of i^{th} pollutant.

Assessment Index Analysis of the Water Quality of Fujiang River

Water quality analysis: Table 3 shows that only FJ1 section in Level III functional zone in Hechuan segment of Fujiang River complies with water quality targets, and water quality in the remaining three sections is considered slightly polluted (Level IV). Only FJ5 section in Level IV functional zone in Hechuan segment complies with water quality targets; water quality in the three remaining sections is considered slightly polluted (Level V). The comprehensive pollution indexes of water quality in two functional zones increase from the upper reaches to the lower reaches. The water quality control target of the lower reaches is Level IV; therefore, the water quality in Hechuan segment gradually becomes poor. FJ4 section is located in the lower reaches of the junction of Fujiang River and its branch Qiongjiang River, the comprehensive pollution index of the water quality of FJ4 section is higher than that of FJ3 section. This finding indicated that the main stream of Fujiang River may be influenced by water quality in the lower reaches of Qiongjiang River.

Analysis of main pollutants in different sections: Table 5 shows that NH_4^+-N is high in all sections, which means that NH_4^+-N is one of main pollutants in water environment of Hechuan segment. The pollution load-sharing ratio of COD_{Mn} in FJ7 and FJ8 sections is obviously higher than that in other sections. The pollution load-sharing ratio of BOD_5 in FJ3 and FJ5 sections is high. In addition, the pollution load-sharing ratio of TP in FJ6 section is apparently higher than that in other sections.

Analysis of Influence Factors for Water Pollution

Retaining structures: Gradient utilization is applied for the main stream of Fujiang River, and many retaining dams and cascade hydropower stations have been built. Caojie Navigation & Electricity Junction in Jialing River significantly influences the water environment of Hechuan segment of Fujiang River. The disturbance of the retaining structures of hydrological processes of riverway mainly refers to the change in the hydrodynamic condition of this segment; thus, the water flow rate is reduced and the hydraulic retention time increased. The pollution indexes of NH_4^+-N and TP in FJ7 section and NH_4^+-N in FJ8 section are high. As a result, the reproduction of algae and floating plants is accelerated, and algal bloom has occurred in Hechuan segment every summer since 2010.

Breeding pollution: ***Boat cage culture:*** Boat cage cultures started in Hechuan segment in 2010. Because the scale of breeding increases yearly, more than 100 owners are practicing. FJ7 Section is one area with boat cage cultures.

Table 4: Assessment results for water quality in different sections of Hechuan segment of Fujiang River.

Tags of sections		Level III functional zone			Level IV functional zone				
		FJ1	FJ2	FJ3	FJ4	FJ5	FJ6	FJ7	FJ8
P_i	DO	0.65	0.70	0.70	0.78	0.54	0.58	0.57	0.62
	NH_4^+-N	0.89	1.23	0.99	1.15	0.97	1.03	1.11	1.21
	TP	0.75	1.11	0.75	1.00	0.59	1.27	1.04	0.90
	COD_{Mn}	0.69	1.04	0.99	1.06	0.85	1.09	1.23	1.28
	BOD_5	0.80	1.20	1.14	1.22	0.96	0.97	0.94	0.96
P_w		0.85	1.17	1.06	1.15	0.88	1.14	1.11	1.14
Pollution level		Clean	Slightly polluted	Slightly polluted	Slightly polluted	Clean polluted	Slightly polluted	Slightly polluted	Slightly polluted

Table 5: Pollution load sharing ratio of water quality in different pollution indexes; unit: %

	FJ1	FJ2	FJ3	FJ4	FJ5	FJ6	FJ7	FJ8
DO	17	13	15	15	14	12	12	13
NH_4^+-N	24	23	22	22	25	21	23	24
TP	20	21	16	19	15	26	21	18
COD_{Mn}	18	20	22	20	22	22	25	26
BOD_5	21	23	25	23	25	20	19	19

Fish cultured in this way may produce plentiful of nitrogen. The statistical data show that 1 t fish may directly produce 40 kg dissolved nitrogen (Hall et al. 1992) in the water. However, 13%-15% feed is not absorbed by fish, and 10%-12% feed is discharged into water in the form of excrement. The phosphorus in feed becomes one of the main sources of that in water (Hu et al. 2010). In addition, the study shows (Zuo et al. 2012) that boat cage cultures may increase COD. The pollution load sharing ratio of NH_4^+-N, TP and COD_{Mn} in FJ7 Section is 23%, 21% and 25%, respectively, which are high levels. Thus, boat cage culture is also a contributor of pollution.

Livestock and poultry breeding: Livestock and poultry breeding along Hechuan segment are common. The urine and excrement of scatter-fed livestock and poultry are discharged freely in a disorderly manner, which influences the water environment of Fujiang River. The pollution load-sharing ratio of NH_4^+-N and TP in FJ1 Section is 24% and 20%, respectively, showing a relationship with livestock and poultry breeding along the segment.

Industrial wastewater: With less awareness for environmental protection, some enterprises along the Fujiang River have insufficient funds, technologies, equipment and control. Thus, the capacity of wastewater treatment equipment is insufficient, and wastewater treatment fails to reach relevant standards. They discharge wastewater that exceeds standards throughout the year by disabling wastewater treatment equipment, laying concealed pipes, selecting time, allowing wastewater to permeate into the ground and mixing cooling water. Directly polluting the river water thus is common. Moreover, the discharging standards of industrial wastewater are considerably higher than that of surface water. Therefore, the concentration of pollutants in wastewater is still high for natural riverways even if most industrial wastewater can be discharged after it reaches relevant standards. Many electroplating and heat treatment enterprises and steel mills are located in FJ6 section; thus, TP severely exceeds standards. The pollution load-sharing ratio is 26%.

Urban and rural domestic pollution: The built area in Hechuan District is 38.88 km^2 with a total population of 432000. Currently, the water supply capacity is 200000 t/day and the daily discharge of domestic and non-domestic wastewater is approximately 150000 t. A large amount of domestic wastewater and a small amount of industrial wastewater from urban and rural areas along the river are discharged into Fujiang River directly without any treatment. In particular, NH_4^+-N and COD severely exceed standard; hence, water fails to satisfy the quality requirements for tourism and drinking water. Urban garbage and industrial residues are commonly dumped, piled and filled in swale along the Fujiang River are common; these wastes likely pollute the river water after a rainy event. Urban sewage pipe network is incomplete and no rain sewage diversion is found in some parts. Thus, the water quality of Fujiang River is influenced because domestic and industrial wastewater cannot be treated in urban treatment plants. Moreover, domestic pollution from ships and fishing boats in Fujiang River cannot be neglected. The load-sharing ratios of NH_4^+-N and COD_{Mn} in FJ8 Section are 24% and 26%, respectively.

Agricultural non-point source pollution: The agricultural land in Hechuan covers approximately 50% of the total area of this district. Chemical fertilizers with abundant nitrogen and phosphorus are applied to agricultural lands; at present, its average absorptive ratio is only 25%. High amounts of fertilizers are lost. In addition, the vegetation coverage in Fujiang River is low, and some pollutants, including high-concentration solid nitrogen, dissolved nitrogen, TP and dissoluble phosphorus, enter Fujiang River via lost water and soil, direct surface runoff, farmland drainage and underground leakage during rainfall or irrigation; these materials are important sources of NH_4^+-N and TP. The amount of pollutants has severely increased in wet seasons.

PREVENTIVE MEASURES

Ecological restoration and protection: The comprehensive control of water pollution shall be integrated into the restoration plan of the ecological system in the entire reach. The effects of soil, vegetation, aquatic organisms, and human activities on water environment should be considered when water pollution is managed. Hillside enclosures for afforestation should be considered to restore vegetation because the land use change caused by deforestation and large-scale agricultural development has damaged the ecological environment in Fujiang River. Vegetation coverage should be improved to prevent soil and water loss as well as dust pollution, filter polluted air, prevent pollutants from entering water bodies, and ensure good water quality of Fujiang River.

Engineering and control methods to protect water quality effectively: The nutrients accumulated in sludge at the bottom of the retaining structures are important causes of reservoir eutrophication. Ecological dredging shall be conducted to accelerate flowing and replacement. The water pollution control in Fujiang River branches, such as Qiongjiang River in the upper reaches, should be enhanced. In Fujiang River, large artificial ecological wetlands, such as Xiaoanxi Wetland Park, should be constructed to purify the quality of water flowing into the river.

Proper control of breeding pollution: The effects of boat cage cultures on water environment are severe because of slow water flow rates in the lower reaches of Fujiang River and low exchange frequency; furthermore, these effects are difficult to control. This breeding method likely causes potential hazards on food safety, flood draining, and navigation. Therefore, boat cage cultures in Fujiang River must be forbidden.

Wastewater from livestock farms along Fujiang River was not treated systematically. In general, dry excrement is collected. However, the wastewater produced by flushing is discharged directly into riverway. Wastewater treatment stations should be established in the main breeding areas to control the discharge of pollutants and to enhance wastewater treatment associated with livestock and poultry breeding. Solid-liquid separation technologies, such as filtration, centrifugation and sedimentation, are applied to pretreat solids and liquid containing high amounts of excrement and feathers in livestock breeding wastewater. These technologies are employed to reduce pollutant load remarkably and prevent equipment blockage or damage (Wang et al. 2014) because large solids or sundries enter the following treatment steps. Aerobic, anaerobic, membrane bioreactor, or sequencing batch activated sludge processes are selected to treat wastewater depending on actual situations.

Control of the discharge of industrial pollution sources: A prominent problem related to industrial wastewater treatment includes inadequate wastewater treatment equipment and facilities; these facilities fail to play their respective roles. The construction of control facilities should be promoted, and wastewater and residue should be recycled. Discharge capacity should be reduced, and the repeating utilization factor of industrial water should be improved; industrial water pollution to Fujiang River and its branches should be eliminated. Meanwhile, management for enterprises along the river will be reinforced, restrictions will be strictly imposed on developing industries with high water consumption and high pollution, advanced production technologies will be promoted, clean production will be advocated, and whole-course pollution control will be conducted. In addition, control of permit systems of pollutant discharge will be strengthened. We will rigidly restrict the pollutant discharge of all functional zones according to their assimilative capacity. Enterprises will be urged to truly carry out their responsibilities in environmental protection through supervision, propaganda and education.

Control of urban domestic wastewater: Currently, technologies for controlling domestic wastewater mainly include bio-contact oxidation biofilm process, biological aerated filter biofilm process, biological rotating disc biofilm process, activated sludge process and membrane bioreactor. Moreover, they shall include nitrogen and phosphorus removal and sterilization and disinfection functions according to requirement of treatment of domestic wastewater.

Wastewater treatment plants and stations along Fujiang River are inadequate. Thus, their planning and construction and supporting pipe networks shall be intensified, and the treatment of domestic wastewater shall be centralized. Relevant rural domestic wastewater control engineering shall be accelerated. Urban and rural sanitation integration projects, as well as domestic waste collection and treatment systems, shall be completed. Investment shall be increased for construction of wastewater pipes and reconstruction of septic tanks.

Control of agricultural non-point source pollution and development of ecological industry: Control of agricultural non-point source pollution shall be reinforced. Pollution of water by farm chemicals and fertilizer shall be reduced; farmers shall be guided to use these chemicals scientifically. Farmers shall be encouraged to use farmyard manure. Ecological agriculture shall be actively developed. Methods of broad irrigation shall be improved. Advanced irrigation technologies, such as pipeline, sprinkling and drip irrigation shall be used for gradually transitioning to water-saving agriculture, which not only effectively utilizes water resources, but also reduces subsiding water in fields. Non-point source loads and pollution of farm chemicals and fertilizer to water shall be reduced comprehensively. Then, ecological industries shall be developed, such as ecological agriculture, breeding, aquaculture and tourism. These industries, which may cause pollution, shall be strictly controlled.

CONCLUSION

On the basis of a comprehensive water pollution index method, we found that the water quality of six out of eight sections in Hechuan Segment of Fujiang River is slightly polluted, the water quality failed to reach Level III and Level IV management targets. In addition, the water quality declines from the upper reaches to the lower reaches.

The water quality indexes in different sections are mainly influenced by various pollution factors, including breeding, industrial wastewater, urban and rural domestic wastewater, and agricultural non-point sources. The water pollution load sharing ratio of NH_4^+-N in eight sections exceeds 20%. Therefore, NH_4^+-N is considered as the main pollutant in the whole course of Hechuan segment. Boat cage cultures increase the water pollution load sharing ratio of NH_4^+-N, TP and COD_{Mn} in FJ7 section. TP in FJ6 section exceeds the standards because of electroplating enterprises, heat treatment plants and steel mills. Urban and rural domestic pollution improves the load sharing ratio of NH_4^+-N and COD_{Mn}. However, agricultural non-point source pollution has become an important source of NH_4^+-N and TP in Fujiang River water flowing into rural areas.

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