General situation and hydrologic characteristics of xijiang river basin

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Abstract. Taking Xijiang River Basin as the research area, this paper introduces the general situation of natural geography of the area, analyzes the hydrological characteristics of precipitation, evaporation, runoff, flood and water quality, analyzes the change law of each hydrological element, and provides the hydrological and meteorological regular data for the regional social and economic construction.

1. Watershed overview

1.1. Geographical location

The main rivers in Xijiang River Basin are Nanpan River, Hongshui River, Qianjiang River, Xunjiang River, Yujiang River, Liujiang River, Guijiang River and Hejiang river. Among them, there are five first-class rivers (catchment area is more than 10000 square kilometers). Many tributaries pass through the second-class steps (topography) of China, with a total drop of about 2130m, with large water energy resources. As the largest main stream in the Pearl River Basin, Xijiang River originates from the east foot of Maxing mountain in Qujing City, Yunnan Province, Yunnan Province. The main stream flows from west to East through Yunnan, Guizhou, Guangxi and Guangdong provinces (regions), and to Sixianjiao Xijiao mouth, Sanshui District, Foshan City, Guangdong Province, with a total length of 2075km and an average gradient of 0.58% [1].

The basin is mainly composed of hills and basins. The river flows from northwest to Southeast. The northwest is Yungui Plateau, while the southeast is dominated by Guangdong and Guangxi. Nanpan River and Hongshui River are the upper reaches of Xijiang River, Qianjiang River and Xunjiang River are the middle reaches, Xijiang River is the lower reaches, and the lower reaches to Modaomen are the estuaries. The upper source of Xijiang River is located in the Yunnan Guizhou Plateau, with an average altitude of about 1000-2500m. It is located at the edge of the plateau with overlapping peaks and rugged ground. Midstream is roughly at the junction of the border of Guizhou and Guangxi, and then descends to the hilly area of Guangxi. The river winds southeast, which is the turbid Hongshui River. At the place where it flows, the vegetation is destroyed, resulting in serious soil erosion, and serious rock weathering, which makes the flow sediment concentration very large, becoming the river with the largest sediment concentration in the Pearl River Basin. The downstream flows from Xijiang
River section to Sixianjiao, Sanshui County, Guangdong Province, which is connected with Beijiang River, and then enters the delta network river area and flows to Haikou.

The Pearl River Basin is rich in hydraulic resources, especially in the upper and middle reaches of the Xijiang River, which provides superior natural conditions for the development of water transport and becomes the second largest waterway in China. At the same time, the hydropower reserves in Xijiang River Basin account for about one twentieth of the whole country [2].

1.2. Main river systems of the basin
Xijiang River Basin in Guangxi is located in 104°28’E~112°35’E,20° 35’N~26°20’N, with a length of 869 km. It is an important water system in Guangxi Zhuang Autonomous Region. The catchment area is about 200000 km², accounting for 85.88% of the total area of Guangxi Administrative Region, and the total water resources account for 85.5% of the total water resources of Guangxi [3].

Nanpan River originates from the east foot of maxing mountain, which is the origin of Xijiang River System in the Pearl River Basin. The drainage area is about 56900 km², with a total length of 914km, average gradient of 1.74% and average elevation of 1645m. The middle and lower reaches of Nanpan River have large longitudinal slopes, many rapids and dangerous shoals, abundant hydraulic resources, and many hydropower stations such as Tianshengqiao have been built.

Beipan River originates from the northern foot of maxing mountain in Zhanyi County, Yunnan Province, flows through Yunnan and Guizhou provinces, and converges in Hongshui River in Guangxi. The river course is 440km long, with an average gradient of 3.42%. The drainage area is about 266km², with an average elevation of 1529m. Huangguoshu waterfall is the most famous of the underground river reach and waterfall.

Hongshui River, the upstream part of the main stream of Xijiang River system, is formed by the confluence of Panjiang River in the South and north of Guizhou Province and Guangxi Zhuang Autonomous Region. The drainage area is about 54900 km², with a total length of 669 km, average gradient of 0.61% and average elevation of 675 m. This section of water has a large sediment concentration, which is not conducive to the construction of water conservancy projects.

Yujiang River is the largest tributary of Xijiang River system. The boundary between Qianjiang and Xunjiang sections of Xijiang River lies in the south of Guangxi. The drainage area is about 90700 km², 70100 km² in Guangxi, accounting for 34.5% of the total area of Xijiang River system. The river is 1151km long, with a total drop of 1655m and a gradient of 0.93%. Flowing through the region, the water flow is gentle, the population density is large, and the economy is relatively developed.

Liujiang River is the second largest tributary of Xijiang River Basin, originated in yousuo Township, Dushan County, Guizhou Province, and covers three provinces (regions) of Guangxi, Guizhou and Hunan. The Liujiang River system is in the form of tree branches, covering an area of about 58300 km². There are many rapids in the upstream channel, and the flow in the middle and lower reaches is gentle, with an average gradient of 1.26%. Most of them are karst and hilly landform with dense population.

Guijiang river, one of the first-class tributaries of Xijiang River system, originates from Maoershan (Huajiang Township, Xing’an County), the first peak of Guangxi, and flows southward to Rongjiang town and Lingqu, which is called Lijiang River. The drainage area is about 18800 km², the river gradient is 0.90%, and the river length is 435km. There are many stone forest caves along the Guijiang river. The water is clear and the scenery is beautiful. It is a famous tourist area in China.

1.3. Climatic characteristics
Xijiang River Basin belongs to subtropical monsoon humid climate, which is warm in winter and cool in summer, rainy in spring and summer, and dry in autumn and winter, resulting in frequent natural disasters such as flood, waterlogging, drought and saltiness. The annual average precipitation is 1080-2760 mm, the annual average temperature is 16.5-23.1 °C, the annual average humidity is 71% - 80%, the annual average wind speed is 0.7-2.7 m/s, and the annual average sunshine time is 1282-2243h. It is a typical continental monsoon climate and oceanic climate.
2. Basic hydrological characteristics

2.1. Precipitation and evaporation

Xijiang River Basin is located in the subtropical zone, with uneven distribution of precipitation in time and space, large rainfall and long duration. The average annual precipitation of the basin is 1499mm, slightly larger than that of the Pearl River Basin. It can be seen from Figure 1 that the annual distribution of precipitation in Xijiang River Basin is uneven, and the flood season (April September) accounts for about 79% of the whole year. The distribution of precipitation in the basin is characterized by more lower reaches and less upper reaches and more East and less West. The areas with the most annual precipitation are mainly located in the east of Liujiang, Guijiang, Yujiang and the lower reaches of Xijiang, with the precipitation more than 1631mm. The areas with the least annual precipitation are mainly located in the upper reaches of Nanpan River and Beipan River, generally lower than 1157mm, and other areas are generally between 1157mm and 1631mm. According to statistics, the annual precipitation of Nanning, Liuzhou, Baise and Wuzhou in Guangxi has an obvious downward trend, on the contrary, Guilin and Hechi have an obvious upward trend.

Figure 1. Distribution characteristics of annual rainfall in Xijiang River Basin

According to statistics, the annual average evaporation of Xijiang River Basin is 998mm. In recent 55 years, the annual evaporation of Xijiang River Basin has been decreasing, and the reduction rate is 9.73mm/a. Due to the influence of temperature, wind speed, solar radiation, air pressure and other factors on evaporation, the distribution of evaporation and precipitation is not even in the same year. The evaporation in flood season (April September) accounts for 61.6% of the annual evaporation [4].

2.2. Runoff

Xijiang River Basin belongs to subtropical monsoon climate, and runoff mainly comes from precipitation supply. Affected by monsoon climate, runoff (2380x108m3) is extremely uneven in the year. The runoff during the flood season (April September) accounts for 77.7% of the total annual runoff. The annual runoff distribution characteristics of the basin are the same as that of the annual precipitation. It can be seen that the precipitation distribution of the basin determines the runoff distribution.

The results show that there are two wet periods and three dry periods in the phase change on the central scale of about 20 years, which have experienced the "dry abundant dry" cycle alternation; there are three wet periods and four dry periods in the phase change on the central scale of about 12 years, which have experienced the cycle alternation of "dry abundant dry abundant dry abundant dry abundant dry" cycle; the runoff on the central scale of about 6 years The change of quantity was frequent. It can be seen that the periodic changes of annual runoff and annual precipitation in Xijiang River Basin are synchronous [5,6]. The interannual variation of Xijiang River Runoff in recent 55 years is shown in Figure 2.
2.3. Sediment

Wuzhou station is the control hydrological station of Xijiang River Basin. The analysis and study of the sediment change characteristics of the station will help to explore the impact of clear water discharge on sediment change after the construction of the reservoir in the middle and upper reaches of Xijiang River Basin. Xijiang River is a river with less sediment, and the average sediment concentration for many years is between 0.032-0.570 kg/m³ (Wuzhou station). However, due to the large annual runoff, the sediment transport volume is large. The annual average sediment transport volume is 61.877 million tons. The runoff mainly comes from Qianjiang River, Yujiang River and Guijiang river, and the sediment mainly comes from Qianjiang River and Yujiang river. Although the annual sediment transport in Xijiang River Basin still keeps a downward trend (Figure 2), it is inconsistent with the change of annual runoff because of the interference of the construction of water conservancy projects and the implementation of water conservation policies, such as returning farmland to forest. See Table 1 for the annual distribution (%) of water and sediment changes in the main hydrological stations of the river system.

Table 1. Annual distribution of water and sediment changes in major hydrological stations of the Xijiang River System (%)

| River   | Station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Flood season |
|---------|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------------|
| Yujiang | Guigang | runoff | 2.5 | 2.2 | 2.5 | 3.6 | 6.5 | 13.9| 17.9| 20.3| 15.2| 7.6 | 4.9 | 2.9 | 81.4 |
|         |         | sediment | 0.1 | 0.1 | 0.2 | 1.2 | 3.8 | 17.9| 28.3| 31 | 16.3| 3.5 | 0.7 | 0.1 | 97.7 |
| Qianjiang | Wuxuan | runoff | 2.5 | 2.4 | 3.1 | 5.3 | 10.9| 19.1| 19.4| 15 | 9.2 | 5.7 | 4.4 | 2.9 | 79.5 |
|         |         | sediment | 0.1 | 0.1 | 0.2 | 1.0 | 7.2 | 29.9| 33.5| 16.7| 17 | 2.7 | 0.7 | 0.2 | 97.7 |
| Guijiang | Pingle | runoff | 2.2 | 3.4 | 5.9 | 13.1| 20.2| 22.0| 22.5| 8.2 | 4.3 | 3.1 | 2.9 | 2.2 | 81.9 |
|         |         | sediment | 0.1 | 0.4 | 1.7 | 14.4| 33.8| 33.3| 10.6| 4.4 | 1.0 | 0.3 | 0.1 | 0.0 | 98.1 |
| Hejiang | Fuyang | runoff | 2.9 | 3.9 | 6.9 | 14.6| 19 | 20.2 | 9.2 | 8.2 | 4.9 | 3.9 | 3.5 | 2.7 | 78.2 |
|         |         | sediment | 0.2 | 0.8 | 2.8 | 21.6| 26.6| 31.1| 7.6 | 7.1 | 0.9 | 0.9 | 0.3 | 0.1 | 96.8 |
| Xijiang | Wuzhou | runoff | 2.4 | 2.5 | 3.3 | 5.9 | 10.9| 17.8| 18.1| 15.5| 10.3| 6.2 | 4.4 | 2.9 | 78.7 |
|         |         | sediment | 0.2 | 0.2 | 0.4 | 2.3 | 8.3 | 26.5| 31.0| 18.5| 8.5 | 3.0 | 0.8 | 0.2 | 95.9 |

2.4. Water quality

As the largest water system in the Pearl River Basin, the study on the evolution trend and influencing factors of water quality of Xijiang River is conducive to the prevention and control of water pollution in the basin, the safety of drinking water for urban residents along the coast, and the rational development of water use for Industry and agriculture. At present, there are some characteristic indexes closely related to the natural environment, such as turbidity, pH value, total hardness, total...
dissolved solids, Dissolved oxygen (DO), permanganate index, Ammonia nitrogen (NH\textsubscript{4}^+-N), Nitrite nitrogen (NO\textsubscript{2}^- -N) and Nitrate nitrogen (NO\textsubscript{3}^- -N).

The results show that the water quality of Yujiang River is generally good in the past 41 years, and it is maintained between class I and class II water quality. The evolution of water environment trend can be divided into two stages: from 1973 to 2000, the water quality became worse, the permanganate index and "three nitrogen" concentration of main pollutants increased, the DO concentration decreased, and the pollution source was mainly industrial pollution; from 2001 to 2013, the water quality improved, the permanganate index and NH\textsubscript{4}^+-N concentration decreased. In addition, the overall water quality characteristics of Xijiang River basin also show the following characteristics: a. The water quality is generally neutral and weakly alkaline; b. the contents of salts and chlorides in all water systems are relatively low; c. the turbidity of surface water systems varies with seasons; d. the hardness of Hongshui River is the largest, followed by Yujiang River; e. the iron and manganese elements show seasonal activity in Yongjiang River and Xunjiang River; f. the water pollution index of Xijiang River system is generally low [7,8].

3. Rainstorm and flood characteristics of the river basin

3.1. Causes and characteristics of heavy rain in the Xijiang River Basin

Xijiang River Basin is rich in water vapor, frequent rainstorm and prone to catastrophic flood. The main weather systems that cause the flood in the basin include: the low-pressure trough in the South Branch and the west wind belt, where the rainstorm is mostly concentrated in March June; Front, before the flood season, the cold air mass from the north of the basin from the east, west, north three invasion, and the basin warm air mass formed continuous rain; the typhoon, the ocean surface in the east of the West Pacific Ocean and the typhoon in the South China Sea bring sufficient water vapor to form the disastrous rainfall; and the low rainfall Short duration of pressure, vortex, shear line, low-level jet and rainfall in small area. Generally, Xijiang River Basin enters flood season from the East in March to April every year, and then expands to the West and south. Three rainstorm high value areas are formed, namely, the mountainous area in South Guangxi, with 3d rainfall of over 700mm; the mountainous area in Northeast and North Guangxi, with 3d maximum rainfall of 537mm; the mountainous area in Central Guangxi, with small rainstorm center. In the lower reaches of Yujiang and Liujiang, there are low value areas [9].

3.2. Analysis of Xijiang Flood Characteristics

Xijiang River Basin has developed water system and diverse topography. Influenced by the weather system, from March to April every year, the frontal rain formed in the East begins to expand gradually to the West and south. Therefore, the eastern region takes the lead in entering the flood season. The Nanpan River and Beipan River in the upper reaches often enter the flood season at the latest, which generally lasts from late May to early November, and the largest flood peak mostly occurs in August. The earliest flood season in Guijiang River generally starts from March to April and lasts until the end of August. The largest flood peak is mostly concentrated in June. The main rivers such as Hongshui River and Yujiang River are mostly interfered by water conservancy projects. The flood season is from May to October, and the maximum flood occurs in June and July.

The flood in Xijiang River Basin is frequent and continuous, and influenced by the regulation and storage of river channel and confluence of river reach, the flood process is mostly of multi peak and multi peak type. The modulus of flood peak is small in the upper and lower reaches of Xijiang River, large in the middle reaches, and the tributaries are Guijiang River and Liujiang River. From June to August every year, it is called the flood season of Xijiang River Basin, which accounts for 80% of the annual water volume. The duration of a flood is generally 30-40 days, and the maximum 30 day flood volume can account for 20-30% of the total annual water volume, even up to 40%. Summarize the flood characteristics: high peak, large quantity, many times and long duration.
The factors of rainstorm formation are complex and the river channel has regulating capacity, which leads to the meeting of the flood peak of the main stream and tributary of Xijiang River, and more floods are often formed. ① If the abnormal weather circulation situation delays the base rain of Guijiang River and the heavy rain of Yujiang River in advance, and the rainfall is large and the duration is long, a large flood will be formed in the lower reaches of Xijiang River. ② The rainstorm center moved to the southeast, which made the flood peak appearing in the lower reaches of Liujiang River and Hongshui River meet in Guijiang River, Yujiang River and Hejiang River, forming a huge flood. ③ According to the data, when the torrential rain occurred at the same time in Xijiang and Beijiang, there were great floods in Xijiang in 1915 and general floods in 1949 [10].

4. Conclusion
Based on the above analysis of runoff, flood and sediment, the Xijiang River Basin is affected by climate and topography. The precipitation in the basin is mainly frontal rain and typhoon rain, and the trend is decreasing from east to west. The annual distribution of water resources in the basin is mainly concentrated in the flood season (April to September), accounting for more than 80% of the total annual amount on average; there are high and low water change cycles (40-45 years main cycle and 25-28 years sub cycle) between years, and the general runoff and rainfall cycles are consistent. The annual distribution of runoff and sediment in Xijiang River Basin is concentrated in the flood season (April September), and the proportion of sediment transport in the whole year is 95.9% - 98.1%, among which the contribution rate of Qianjiang River and Yujiang River is 91.3%. Similar to runoff, there are periodic changes in sediment transport (in the main period of 20-23 years, and in the sub periods of 10-13 years and 4-6 years). Including the hydrological characteristic values of evaporation, precipitation, runoff, sediment transport and so on, the overall trend of decline over the years, but different from the sediment transport, the decline of evaporation, precipitation and so on is due to climate change, but the decline of sediment transport is also related to the ecological engineering construction and water conservancy engineering construction in the basin. In addition, the indicators of water quality in the basin are getting better year by year. The main flood disaster in Xijiang River Basin is rainstorm flood, so we should strengthen the construction of flood forecast system, so as to reduce the impact of flood disaster, and actively improve the role of Xijiang River System in economic development.

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