

Analysis of changes of relationship between water level and discharge and its causes at the tail of Fuhe River in recent 70 years

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Abstract. Based on the measured day-averaged water level and discharge data of the tail reach of Fuhe River, the changes of hydrological situation in recent 70 years was analysed in this paper. The results show that the relationship between the water level and discharge at the tail of Fuhe River has been greatly changed, and the water level at the same discharge was significantly reduced. These changed were not related to the runoff changes, but mainly affected by the changes of river bed and downstream boundary water level.

1 Introduction

Over the years, under the multiple effects of non-human and human factors, the hydrological situation of Poyang Lake region has been significantly changed [1-3]. It is obvious that that the relationship between water level and discharge in the tail areas of the five major in-lake river systems has also changed. Among them, Ganjiang River tail is especially concerned by many scholars for its important political and economic status [4-5]. Fuhe River Basin, located in the southeast of Jiangxi Province, is one of the five major rivers in Poyang Lake system. It passes through Jiaoshi barrage and Qinglan lake and flows into Poyang Lake in Sanyang. The tail of Fuhe River has a similar economic and social status to that of Ganjiang Rive. It is also an important habitat for migratory birds, zooplankton and aquatic plants. However, the change of its hydrological situation has not attracted enough attention. Based on the historical hydrological data of this area, this paper analyses the hydrological situation, as well as the internal mechanism driving its changes. The relevant research results can provide technical support for the development, utilization and protection of Fuhe River.

2 Study area, data and method

2.1 Study area and data

Fuhe River is one of the five main rivers in Poyang Lake system. The Fuhe River basin is located in the southeast of Jiangxi Province, spanning 115°30' to 117°10' E and 26°30' to 28°27' N. The river runs from south to north with a total length of 349km and a basin area of 17186km². The length from Heyuan to Nancheng is

158km, called Xujiang River, which is the upper reach with a width of about 200-400m and an average gradient of 3.4 ‰; the middle reaches from Nancheng to Fuzhou is 77.4km in length, with a width of 400-600m and an average gradient of 0.44 ‰; the Fuhe River flows into the downstream plain area after passing through Fuzhou City and flows into the downstream plain area, with a width of 400-1000m. Among this, Fuzhou to Lijiadu is about 42.6km in length, with an average gradient of 0.26 ‰. Downstream Lijiadu to Sanyang, the study area in this paper, is 71km long with an average slope of 0.15 ‰ shown as Figure 1.

In this section, there is a Lijiadu hydrological station, which controls the inflow of Fuhe River into the Poyang lake, and has the daily average water level and discharge observation data since 1956. There are another two water level observation stations, called as Wenzhen station and Sanyang station in the lower reaches of Lijiadu. Wenzhen station has continuous water level observation data since 1970s, and Sanyang station has continuous water level observation data since 1950s. The daily average water level and discharge data of the three hydrological stations constitute the database of this study.

2.2 Method

The change of hydrological situation is mainly reflected by the change of relationship curves between the water level Z and discharge Q . In this study, the relationship curve between water level and discharge is drawn by a standardized data series. The standardization method is as follows:

$$Q_s = (Q_i - Q_{min}) / (Q_{max} - Q_{min})$$
$$Z_s = (Z_i - Z_{min}) / (Z_{max} - Z_{min})$$

Where Q_i and Z_i are the daily average flow discharge and water level, Q_{min} and Z_{min} are the minimum value

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of flow and water level, and Q_{min} and Z_{min} are the maximum value. After the above-mentioned standardization process, the relationship between standardized water level and discharge of each year is plotted on the same map. The historical change of hydrological situation can be clearly reflected by the change of data distribution area in each year.



Fig. 1. Map of the study area.

The causes of the change are mainly analysed from three aspects: runoff, river bed evolution and down boundary water level conditions. The change of runoff is mainly reflected by the annual average runoff. The influence of river bed evolution and lower boundary water level conditions is mainly reflected in the water level correlation between upstream and downstream. Through the change of correlation relationship, we can distinguish the influence of river bed evolution and lower boundary water level conditions.

3 Results

3.1 Change of $Q \sim Z$ relationship

Figure 2 shows the variation of $Q \sim Z$ relationship at Lijiadu hydrological station over the 60 years. It can be clearly seen from the figure that the water level of Lijiadu hydrological station under the same discharge is in a continuous decline process, and the decline range is

relatively large. From 1956 to 2019, the drawdown range of water level under different discharge is 1.9 m to 4.2 m.

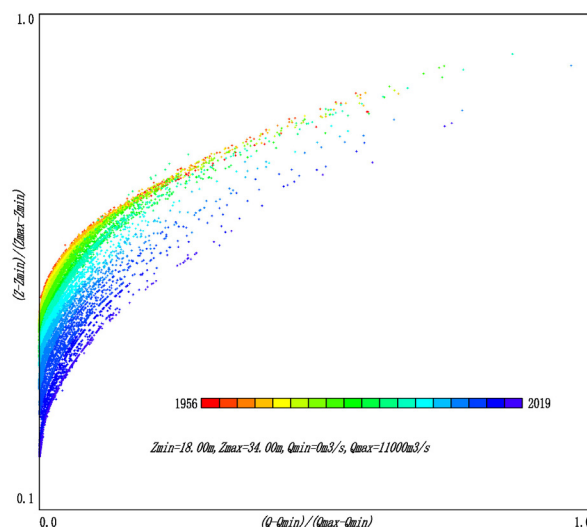


Fig. 2. Map of the changes of $Q \sim Z$ relationship.

Table 1 gives the water level drop of different discharge. It can be seen that the greater the discharge, the smaller the water level drop. For example, the water levels of 1000m³/s, 3000 m³/s and 5000 m³/s in 1956 are 27.7m, 29.4m and 30.0m respectively. And in 2019, the corresponding water levels are 24.5m, 27.0m and 28.7m, with the decrease range of 3.1m, 2.4m and 1.3m respectively.

Table 1. Water level drop of different discharge.

Discharge (m ³ /s)	Water Level (m)		Water Level drop (m)
	1956	2019	
500	26.8	23.5	-3.3
1000	27.7	24.5	-3.1
1500	28.2	25.1	-3.1
2000	28.6	25.7	-2.9
2500	29.0	26.3	-2.6
3000	29.4	27.0	-2.4
3500	29.8	27.6	-2.2
4000	30.1	28.1	-1.9
4500	29.9	28.5	-1.4
5000	30.0	28.7	-1.3

Figure 3 gives an annual-averaged water level from 1960 to 2019. From the declining trend over the years, the rate of water level decline was small before 2000, but increased after that.

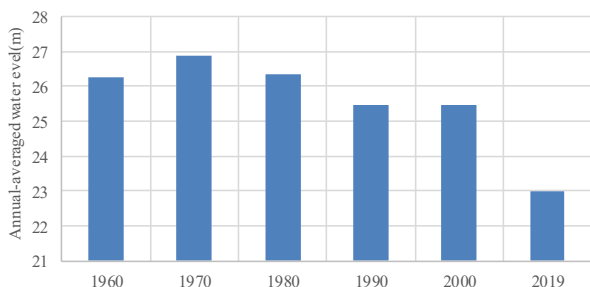


Fig. 3. Annual-averaged water level from 1960 to 2019.

3.2.1 Influence of the runoff

Runoff is the primary factor affecting the water level of the reach, and the change of runoff will deeply affect the water level. Figure 4 shows the annual average runoff of Lijiadu station over the years. It can be seen from the figure that the average annual runoff of Lijiadu has not changed significantly over the years. From the 10-year moving average line we can see, that it has even increased slightly in recent 10 years. Therefore, runoff is not the reason for the downward movement of Lijiadu stage's Q~Z relationship.

3.2 Reasons of the changes

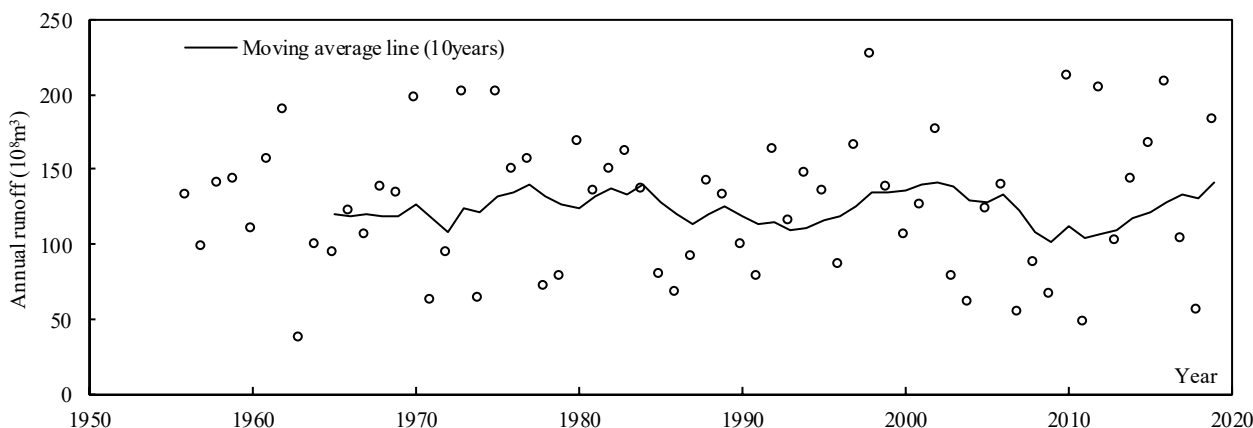


Fig. 4. Map of annual runoff of Lijiadu station.

3.2.2 Influence of the river bed evolution and lower boundary water level conditions

There are many aspects of river bed evolution, such as river bed degradation/erosion, regulation, and river-related projection. The influence of the above-mentioned changes on the water level in a reach is finally reflected in the water level correlation between the upstream and downstream of the reach. Figure 5 ~ Figure 6 show the variation of water level correlation ship of the upstream and downstream water level stations in the study reach. It can be seen from the figures that the overall change of water level correlation between Lijiadu station and Wenzhen station is relatively small. Among them, Lijiadu water level rose about 0.4m under the same water level in Wenzhazhen during the middle water period from 1956 to 1990, and the riverbed change is the main reason for the basically stable Lijiadu water level in this period; the water level correlation between the two stations has little change from 1990 to 2010. During the dry season from 2010 to 2018, the water level of Lijiadu decreased by about 1.0m under the same water level in Wenzhazhen, accounting for about 30% of the decline value of Lijiadu water level in the same period, while the impact value of the downstream water level

decline accounted for about 70%, which is the main reason for the water level decline of Lijiadu.

The water level correlation between Wenzhazhen and Sanyang is scattered due to the supporting effect of Poyang Lake. From the change trend, the correlation between the two had little change before 1970. During the dry season from 1970 to 1990, the drawdown value of Wenzhazhen station was about 0.5 m under the same water level at Sanyang station, accounting for 50% of the water level decline value of Wenzhazhen station. Compared with that in 2018, the drawdown value of Wenzhazhen is about 1.9m, accounting for about 85% of the water level drop value of Wenzhazhen. The water level decline of wenzhazhen is mainly affected by the water level drop of Sanyang station downstream.

4 Conclusions

The analysis shows that the hydrological situation in the Fuhe River tail has changed greatly in the past 70 years, and the water level under the same discharge has decreased obviously. This phenomenon has little relationship with the change of runoff, which is mainly affected by the changes of riverbed itself and the water level change in the downstream Poyang Lake are.

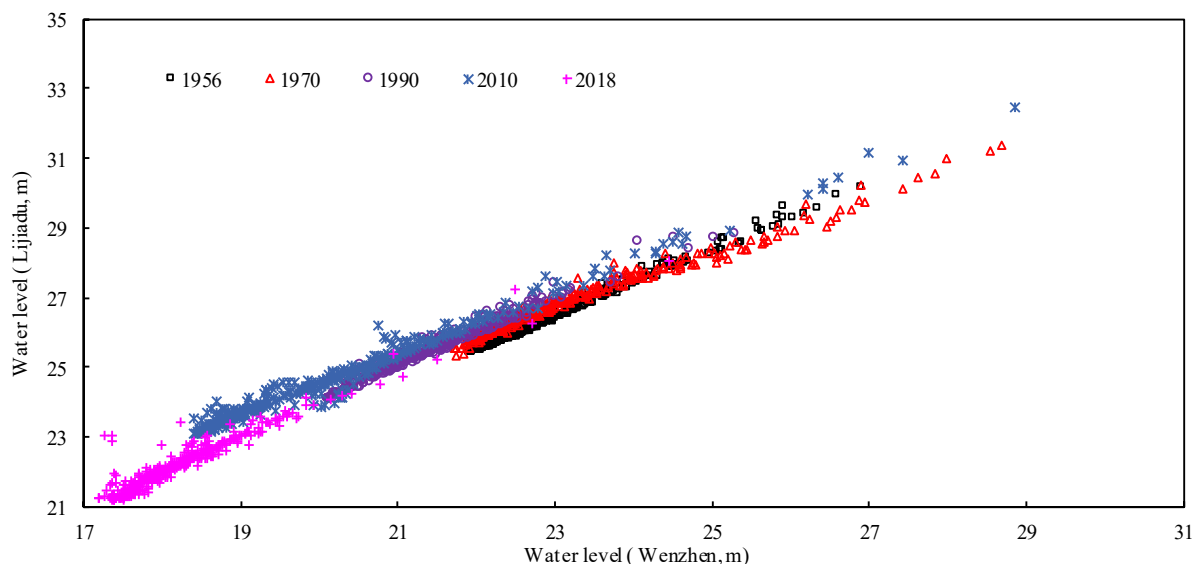


Fig. 5. Water level correlation ship between Lijiadu and Wenzhen.

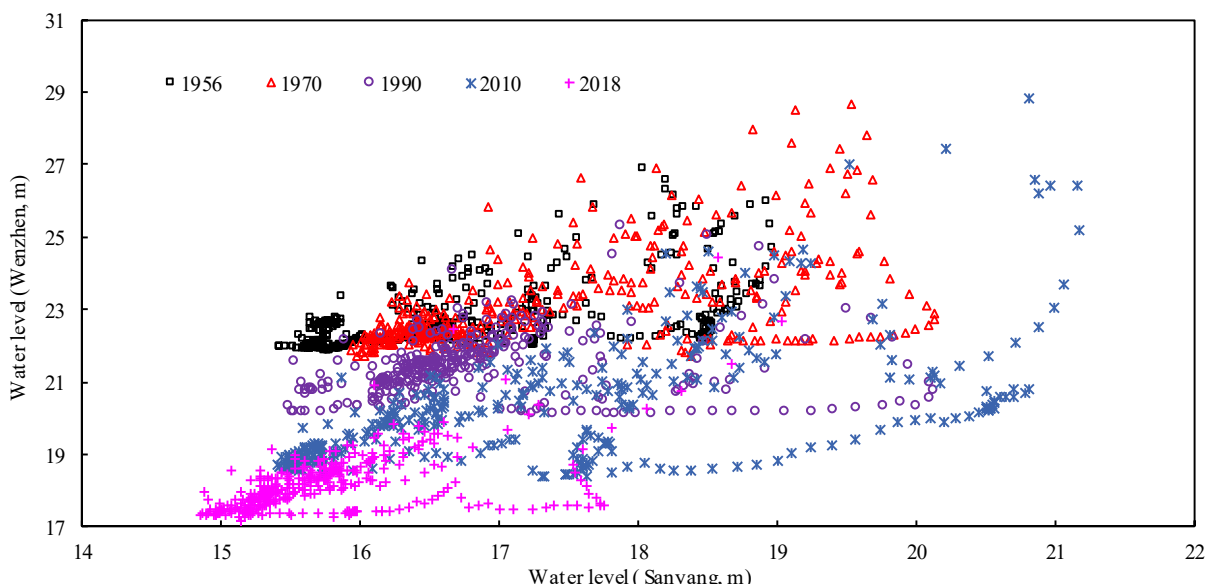


Fig. 6. Water level correlation ship between Wenzhen and Sanyang.

Acknowledgments

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