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The Change and Effect Factors of Water Level in Jingjiang River

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Abstract

Based on the measured data from 1957 to 2007 in Jingjiang river, this paper analyzed the water level change in Jingjiang river in low water and bank-full discharge, and then established the relationship between the value of water level change and river sediment scour-silt amount with the measured topographic data after the cut-off. The results show that the relations are well at Shashi and Xinchang stations while the correlation is not obvious at Jianli station. Finally, the paper analyzed the influencing factors of water level change in Jingjiang river in view of the water and sediment changes before and after the impoundment of Three Gorges reservoir and found that the recent water level change in Jingjiang river is mainly caused by the incoming sediment concentration change in the main stream of Changjiang river.

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1. Introduction

Jingjiang river is about 340km long, flowing from Zhicheng to the mouth of Dongting lake located in the Chenglingji. It’s divided into upper and lower Jingjiang bounded by Ouchi. The upper Jingjiang, about 167km long, is slightly curved braided river, while the lower Jingjiang is the typical meandering river about 170km long. The tributary Juzhang flows into Jingjiang from the northern bank, along the south bank Songzi mouth, Taiping mouth and Ouchi mouth respectively diverge into Dongting lake,

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which again flows into Changjiang river at Chenglingji gathering the main four tributaries Xiang river, Zhi river, Yuan river, Li river, forming a complex relation between river and lake. In recent decades, Jingjiang implemented a series of large river regulation and water conservancy projects, including the Jingjiang flood diversion project, systematic cut-offs in lower Jingjiang, Gezhouba and the Three Gorges hydro-junctions, the implementation of those projects caused sediment discharge and boundary conditions change to varying degrees and made the water level of Jingjiang river greatly changed, which have brought greater influence to the decision-making on the Jingjiang river and Dongting lake area, and also attracted wide attentions. In this paper, according to the observed data of channel topography from 1972, we calculated the bed scour-silt changes in Jingjiang river using section topography method, studied the water level change and the relations between water level and sediment quantity of scour-silt under different discharges, and finally analyzed the influencing factors of water level change in Jingjiang river.

Figure 1. River regime map of Jingjiang reach

2. Water level change of Jingjiang River

2.1. Water level change at Zhicheng

The water level of Zhicheng at low flow began decreasing since 1980, as figure 2 shows, in 1987, the water level decreased by about 0.66m as compared with 1981, then it slowed down, dropped about 0.1m in 1991 compared with 1987, there was no significant changes in water level from 1991 to 2003, the water level further dropped after the impounding of the Three Gorges reservoir, but only slightly, falling by about 0.15m in 2007 than in 2003. The water level reduction extent of Zhicheng was lesser under the bankfull discharge, the water level in 1991 reduced by about 0.3m than in 1981, and then it was basically stable and had no significant decline after the impoundment of Three Gorges reservoir.

2.2. Water level change at Shashi

Figure 2. Comparison of water level over time in different flowrate at Zhicheng station[1-5] (left)
Figure 3. Comparison of water level over time in different flowrate at Shashi station[1-5] (right)
The water level change at Shashi station is shown in Figure 3, the water level of 1975 (after cut-off) reduced by 1.3m compared with 1966 (before cut-off), between 1975-1980 the water level remained stable and increased slightly. Since 1980, affected by the river erosion in the downstream after the implementation of Gezhouba reservoir, the water level again dropped, down to 1993 reduced by about 1.2m. Water level remained stable and increased by about 0.1m during 1993-1998, however, since the operation of Three Gorges reservoir in 2003, again affected by the river erosion, the water level of Shashi under low flow reduced by about 0.6m in 2007 compared with 2003. The declining scale is lesser under the bankfull discharge, and the water level in 2007 fell by about 1.9m than that in 1967 and about 0.2m than that in 2003.

2.3. Water level change at Jianli

The water level at Jianli station didn’t show a single trend affected by the jacking of Dongting Lake outflow (Figure 4). The water level in 1966-1975 under the low flow reduced by about 0.7m compared with that in 1957-1966, then it slightly recovered by about 0.2m in 1975-1980. The water level was basically stable until 1988, then affected by the increasing river erosion, the water level in 2003 decreased by about 0.3m than that in 1988. After the impoundment of Three Gorges reservoir the water level was basically stable and had no significant variation. The water level in 1966-1975 under the bankfull discharge decreased by about 0.3m compared with 1957-1966, then it slowed down to the lowest in 1987, then it again increased slightly, but remained relatively stable and had no significant changes after the impoundment of Three Gorges reservoir.

3. The correlation between water level change and amount of river erosion and deposition

In the Jingjiang river beach, from Zhicheng to Yangjiaanao it is the sand with a small amount of cobles and gravel bed, but it is sandy riverbed in the downstream of Yangjiaanao, in this river reach sediment is easily washed. The measured data before impoundment confirms that Jingjiang river reach is on the scour status in 1957-1993, while it’s in a state of micro-silting from 1993 to 1998 and then it again is in a state of erosion between 1998 and 2007. It took place three times cut-off in Jiangjiang river between 1966 and 1972, resulting in river reduction 72km and a huge river regime change, Gezhouba reservoir began impounding in 1980 and the Three Gorges also began to run in 2003, which was bound to significantly affecting water level change of the river reach, so in the following, we’ll use the water level change value and its matching sediment quantity of scour-silt during the period 1972-1975, 1975-1985, 1985-1993, 1993-1998 and 1998-2007 after the cut-offs to establish a correlation between the two. Figure 5-7 shows the correlation between the water level change value and its matching sediment quantity of scour-silt at Shashi, Xinchang and Jianli stations. From Figure 5-7 we can see, between the water level changes at
Shashi and Xinchang stations and the erosion and deposition volume of Jingjiang river reach, there is a positive correlation, and the Jingjiang River is in a state of silting when the water level increases, and the water level drops while it is in the washing. The water level changes at Jianli station are also proportional to erosion and deposition volume of Jingjiang river reach, the correlation is better in the low flow, but under the large and medium flow level the relationship between the two is dispersed, in addition, the value of water level change is quite large, and the changing magnitude at high water level is obviously larger than that at low level. The main reason is: in addition to the influence of the river erosion and deposition volume, the water level change of the station is also affected by the impact of water level change of Chenglingji, and in most cases it is affected by water surface gradient and the outflow of Dongting Lake. The water surface gradient is quite large in the low flow, the influence range of backwater from Dongting Lake is rather small, so the water level at Jianli is slightly influenced by that of Chenglingji, there is a Google correlation between the water level change and sediment quantity of scour-silt under low flow, while under medium and large flow, river water surface slope changes slow, and the influence range resulted from the outflow backwater of Dongting lake becomes bigger, so that the correlation between the two at Jianli is quite poor.

4. The influence factors of water level change in Jingjiang reach

The water level change in Jingjiang river reach is closely linked to the flow-sediment variation of the main stream, before impoundment, because of the heavy sediment in the mainstream of the Changjiang River, Dongting Lake was in a state of long-term siltation, correspondingly the shunt flood channel was silting-up, the runoff and sediment from the three outfalls decreased, resulting in the value of water and sediment increased in Jingjiang river, then river sediment carrying capacity increased and river erosion enhanced. The three cut-offs of lower Jingjiang between 1966-1972 aggravated river erosion, leading to further water level decline of Jingjiang river reach, these runoff and sediment diversion changes between river and lake caused that the incoming sediment of Chenglingji-Hankou river reach increased, river sediment deposited, the water level of Chenglingji elevated, backwater effects increased, restraining the water level reduction of Jingjiang river, but this effect was only on the lower Jingjiang river and had an quite weak effect on the Xinchang river reach and its upstream. So the main reason for the water level decline in Jingjiang river before impoundment was that the sediment and runoff diversion from the three outflow decreased, and the fundamental reason lied in the high sediment concentration in the mainstream of Changjiang River.

After the impoundment of Three Gorges reservoir, the sediment concentration of mainstream significantly reduced, and the water level dropped which was caused by the erosion to resume the sediment concentration, the erosion developed from the upstream to the downstream, and upstream
erosion rate is greater compared with the downstream, so that the bed slope become leveling and bed material load coarsened, sediment carrying capacity reduced along the river, the water level decline was limited, and the decline rate in high flow was smaller than that in medium and low flow. Because Yichang-Zhicheng river reach located in the upstream is pebble bed, it will be in an equilibrium scour state at a short time after impoundment, and Jingjiang river reach will be in the erosion state very soon. According to the stage-discharge relation of 2003 and 2007 at the main stations of the Jingjiang river reach, after the impoundment when the flow was 5000m$^3$/s, the water level of Zhicheng and Shashi reduced by 0.15m and 0.6m respectively, and the water level of Jianli decreased slightly compared with 2003 (before impoundment), when the discharge was equal to 20000m$^3$/s, the water level of Zhicheng, Shashi and Jianli decreased by about 0.2m, 0.24m and 0.04m respectively, when the discharge equaled 40000m$^3$/s the water level of the three stations were basically stable, the above-mentioned results show that the water level of Jingjiang river reach change insignificantly. From the above analysis, we can see that water level reduction of Jingjiang river is mainly caused by the decreasing sediment concentration in the mainstream of Changjiang River.

5. Conclusion

Based on the analysis of sediment quantity of scour-silt change, water level change and the influencing factors, we can get the following preliminary understandings:

(1) The water level at Zhicheng in 2007 reduced by about 0.9m compared with that in 1981 in low flow, but the decline rate was quite small in bank-full discharge, and it has been basically stable since 1991. The water level at Shashi station in 2007 dropped by about 3.7m than that in 1966 in low flow, but the decline value was about 1.9m in bank-full discharge. Affected by the backwater effect of Dongting Lake outflow, the water level at Jianli station didn’t present a single change trend.

(2) Between the water level change at Shashi and Xinchang stations and the erosion and deposition volume of Jingjiang reach, there is a positive correlation. The water level change at Jianli station are also proportional to erosion and deposition volume of Jingjiang river reach, the correlation is better in low flow, but under the large and medium flow rate the relationship between the two dispersed, in addition, the value of water level change is quite large, and the changing magnitude at high water level is obviously larger than that at low level.

(3) Before impoundment, the main reason for the water level decline in Jingjiang river was that the sediment and runoff diversion from the three outflow decreased, and the fundamental reason lied in the high sediment concentration in the mainstream of Changjiang River, but after the impoundment it is mainly caused by the decreasing sediment concentration in the mainstream of Changjiang River.

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