Study on evolution characteristics of a near-dam channel downstream of the Three Gorges Reservoir

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Abstract. Riverbed scouring and silting is strongly related to flood control, navigation, water intake and so on. Therefore, a deep understanding of the scouring and silting characteristics of the near dam river reach is the premise of the optimal operation of the Three Gorges Reservoir. Based on the four times topographic data of the near dam reach after the impoundment of the Three Gorges Reservoir, the scouring and silting characteristics were studied in this paper. The results show that, after the impoundment of the Three Gorges Reservoir, except for the siltation of deep channel in some years, the other reaches had shown a scouring, and the scouring is concentrated in the low flow channel, and the change of channel above the flat is small.

1. Introduction

The Three Gorges project is a key project for harnessing the Yangtze River and exploiting its water resources. It has great comprehensive benefits in flood control, power generation, shipping and water supply [1]. Before the impoundment and operation of the Three Gorges project, after years of natural evolution and river regulation, the river regime in the middle and lower reaches of the Yangtze River was basically stable, and the changes of erosion and deposition were basically compatible with the incoming water and sediment conditions [2]. After the impoundment and operation of the Three Gorges reservoir, the conditions of water and sediment in the downstream of the dam have changed greatly, and the channel has undergone severe scouring and silting adjustment [3-5]. Corresponding to the adjustment of flood channel after channel scouring, the relationship between water level and discharge, discharge capacity and storage capacity of channel under high water level may change correspondingly [6-9]. After the joint operation of the Three Gorges Project and the upstream reservoir, great comprehensive benefits will be brought into play, and at the same time, it may also have a certain impact on the river regime stability and flood control safety. Therefore, based on the measured topographic data of Tiaoguan reach, a typical reach in the lower reaches of the Three Gorges reservoir near the dam, its erosion and deposition amount and distribution characteristics were analysed in this paper. The research results can provide technical support for the operation of the Three Gorges reservoir.

2. Study area, data and method

2.1. Study area

Tiaoguan reach is located in the downstream of Shishou, about 300 km away from the Three Gorges Dam. It is about 40.8 km long from Beinianziwan to Egongtu. It is composed of three reverse bends: Jinyugou, Lianxinyuan and Zhongzhouzi. The right bank of the reach is divided by a regulating mouth. It was controlled by a sluice in 1959. The location and geomorphology of the study reach are shown in Figure 1.

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2.2. Data
In this study, the measured topographic data in 2002, 2006, 2011, 2013 and 2016 were collected for the calculation of erosion and deposition.

2.3. Method
Firstly, orthogonal curvilinear grid is used to divide the study reach. Then, the grid node elevation is interpolated according to the measured terrain data. The distribution map of riverbed erosion and deposition is drawn by using the interpolated grid terrain. The amount of erosion and deposition is calculated according to the erosion and deposition thickness of grid nodes. The amount of erosion and deposition of each grid is calculated according to the area of the grid and the thickness of erosion and deposition at the centre of the grid. The amount of erosion and deposition of the whole reach can be obtained by grid accumulation of the whole reach.

Figure 1. Location of the study area and its geomorphology.
3. Results

3.1. Erosion and deposition amount

Figure 2 shows the amount of erosion and deposition at different elevations of the study reach. It can be seen from the figure that:

From 2002 to 2006, the river channel below 5m elevation in this reach was in the state of siltation as a whole, the river channel within 15m to the level of flat water was in the state of scouring, and the scouring degree of each elevation was relatively severe, while the river channel above the level of flat water changed little or even slightly silted.

From 2006 to 2011, the channel below 25m elevation of this reach showed scouring, and the scouring intensity was significantly greater than that of 2002-2006. The channel above 25m showed siltation, but the siltation intensity was not large. The average annual siltation amount above 25m was about 1.4 million m$^3$, and the average annual siltation thickness was about 0.02m.

From 2011 to 2013, the erosion intensity of low flow channel in this reach decreased, with an average annual erosion of about 2.75 million m$^3$ for the channel below 25m, obvious erosion for the channel above 25m, and an average annual erosion intensity of about 7 million m$^3$ for the channel between 25m and 35m.

From 2013 to 2016, except for the low flow channel, the erosion and deposition of the channel above 15m had little change.

3.2. Distribution and characteristics of scouring and silting in shoal and channel

Figure 3 shows the distribution of erosion and deposition at different elevations of the study reach. It can be seen from the figure that During the initial impoundment period of the Three Gorges Reservoir, some deep channels were silted up, and the channel below the flat was in a continuous scouring state, and the scouring intensity was relatively high before 2011. From 2011 to 2013, the scouring intensity of the low flow channel weakened, and the scouring intensity above the low flow channel increased. After 2013, the low flow channel continued to scour, and the scouring intensity above the low flow channel was not large. It is easy to see from the comprehensive development trend of scouring and silting that the reach from Beinianziwan to Egongtu is mainly scoured by low flow channel, while the channel from low flow channel to bank full channel is scoured slightly with little intensity, and the overall scouring above bank full channel is not obvious. Corresponding to channel erosion and deposition, the low flow channel expands and the channel area increases significantly after erosion.

Figure 2. The amount of scouring and silting at different elevations in different periods.

Figure 3. The distribution of erosion and deposition at different elevations of the study reach.
4. Conclusions
In this paper, the characteristics of erosion and deposition in the downstream reach of the Three Gorges Reservoir near the dam are analysed based on four measured topographic data. The results show that the channel scour of the studied reach is severe from the impoundment of the Three Gorges Reservoir to 2006, and then to 2011, the channel scour of the low flow reaches continues to be strong, the channel scour of the low flow reaches to the flat reaches tends to be slow, and the channel scour of the low flow reaches also tends to be slow after 2011. From the impoundment of the Three Gorges Reservoir to 2016, the scour of this reach is mainly concentrated in the channel below the flat, and the channel above the flat has little change, with slight scour, and the average scour thickness is about 0.2m.

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