RESEARCH ON RIVERBED ADJUSTMENT RESPONSE OF JINGJIANG REACH UNDER THE CHANGE OF FLOW AND SEDIMENT

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Abstract. According to the hydrological and sediment data before and after the impoundment in the Three Gorges Reservoir and the measured topographic data of Jingjiang Reach, the article analyzes the response mechanism of erosion and deposition of riverbed in Jingjiang Reach for flow changes, suspended sediment recovery and bed material compensation, makes a judgment of the terrain adjustment trend of the reach in the future. The main conclusions are as follows: After the impoundment of Three Georges Reservoir, the low flow has increasing and streamwise recovery of suspended load strengthen the scouring ability of the overall Jingjiang Reach. After the impoundment of Three Georges Reservoir, the Jingjiang Reach shows conforming and cumulative erosion; the low flow channel is the principal part of riverbed scouring.
Keywords: *Three Gorges Reservoir, erosion, deposition, Yangtze River, China, hydrology*

Introduction

Reservoir building is a human activity exerting the largest and longest impact and interference on rivers (Dolan and Howard, 1974; Graf, 1999; Liu et al., 2013). After a hydro-junction is built on a natural river, the water and sediment inflow conditions under the dam will be changed significantly, the bed load and the bed material load will be hindered in the reservoir and clear water or muddy water containing non-bed material load will be discharged(Petts and Gurnell, 2005; Meade and Moody, 2010; Yang et al., 2011; Allison et al., 2012). According to statistics (Dai et al., 2009; Yang et al., 2015), after the impoundment of the Three Gorges Reservoir, the average sediment runoff of Yichang Hydrologic Station downstream for many years is reduced by about 90% comparing with that before impoundment, approaching to "discharge of clear water". Along with that many hydro-junctions on the upper reaches of Yangtze River are put into operation, the decreasing trend of sediment runoff of Jingjiang Reach will be ongoing. The changes of flow and sediment conditions will inevitably lead to erosion and deposition of riverbed, while erosion and deposition will certainly require corresponding adjustment of the cross section, longitudinal gradient and river pattern of riverbed to adapt to the changed flow and sediment conditions and achieve dynamic balance (Wang et al., 2013). Since changes are long-playing and long-distance(Brandt, 2000; Chu et al., 2013; Yang et al., 2014), new challenges are imposed on channel

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improvement of Jingjiang Reach. Based on hydrology and sediment data before and after the impoundment of the Three Gorges Reservoir and the actually measured topographical data of Jingjiang Reach, this study analyzes the response of erosion and deposition of Jingjiang riverbed to flow changes and sediment change, discussion the riverbed erosion and deposition trend.

Studied reaches and data source

Studied reaches

Jingjiang Reach lies in the middle reaches of Yangtze River, stretches from Zhicheng to the outlet of Dongting Lake "Chenglingji", and the full length is about 347.2km. The reach from Zhicheng to Ouchikou is the upper Jingjiang Reach, which is 171.7km in length; it is a curved braided river reach and composed of six curved reaches including Jiangkou, Shashi, Haoxue, Yangxi, Woshi and Gongan, wherein the tributary "Juzhang River" flows in at the north bank and Songzikou and Taipingkou respectively flow into Dongting Lake at the south bank. The reach from Ouchikou to Chenglingji is the lower Jingjiang Reach, which is 175.5km in length; it is a restricted curved channel and composed of ten curved reaches including Shishou, Shatanzi, Tiaoguan, Zhongzhouzi, Jianli, Shangchewan, Jingjiangmen, Xiongjiazhou, Qigongling and Guanyinzhou, wherein Ouchikou and Tiaoxiankou (closed and constructed in 1959) respectively flow into Dongting Lake at the south bank. Dongting Lake concentrates four rivers such as Xiang, Zi, Yuan and Li, carries the flow and sediment discharged from Songzikou, Taipingkou and Ouchikou at Chenglingj and affluxes to Yangtze River. Please see *Figure 1* for the river regime chart and plan of Jingjiang Channel.

Figure 1. *River regime chart of Jingjiang*

Data source

The hydrologic stations in Jingjiang Reach are mainly arranged in Zhicheng, Shashi, Jianli and Luoshan, which respectively stand for the control stations of the inlet of Jingjiang Reach, upper Jingjiang Reach and lower Jingjiang Reach. Moreover, Yichang Station is the outbound hydrologic station of the Three Gorges Reservoir and located on the upper stream of Jingjiang Reach and can reflect the flow and sediment changes most directly after the operation of the Three Gorges. Hankou Hydrologic Station resides in the down stream of Jingjiang River and is the basic control station of water regimen after the stem stream of Yangtze River flows into Han River. As the control hydrologic station downstream, Hankou Station can reflect the flow and sediment situation after the

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discharged water of the Three Gorges is supplied at the riverbed of Jingjiang reach. The hydrology and sediment data of Yichang Station, Zhicheng Station, Shashi Station, Jianli Station, Luoshan Station and Hankou Station and the suspended sediment particles and grading data from 1987 to 2014 are collected. The bed material particles and grading data of Jingjiang Reach are also sorted out. In addition, in this study, the data concerning the terrain and silt dash quantity changes Jingjiang Reach from 2002 to 2014 are also collected.

Riverbed erosion and deposition adjustment features of Jingjiang Reach after the impoundment of the Three Gorges Reservoir

Overall erosion and deposition features

Jingjiang Reach is a sandy reach which is nearest to the Three Gorges Reservoir. Influenced by the discharge of "clear water" after the impoundment by the Three Gorges Reservoir in June 2003, the reach scours cumulatively and violently, but the overall regime is basically stable. From October 2002 to October 2014, the accumulative scouring intensity of shoal channel of Jingjiang Reach is 2,281,000m^3/km.

Figure 2 and *Figure 3* provide the accumulative scouring intensity of the upper and lower Jingjiang reaches after the impoundment from 2003 and 2014 compared with that in October 2002, wherein the oued channel, basic channel and shoal channel correspond to the channels of 5,000m^3/s, 10,000m^3/s and 30,000m^3/s of Yichang flow respectively. Seen from the erosion and deposition law of channel parts with different features, the oued channel, basic channel and shoal channel of the upper and lower Jingjiang reaches after impoundment are in a constant scouring state and the erosion and deposition intensity change law along with time is basically consistent. According to the fact that the scouring intensity changes along with the time, at the initial stage after the impoundment, the scouring amount is larger, but the accumulative speed increasing of subsequent scouring amount slows down. After entering the testing impoundment period since October 2008, the accumulative scouring amount of the reach enters the rapid increasing state and the scouring intensity of the upper and lower Jingjiang reaches during the testing impoundment period are larger than that from 2003 to 2008. For example, the annual average scouring intensity of shoal channel of the upper and lower Jingjiang reaches from October 2007 to October 2008 are respectively 14,500m^3/km and 4,400m^3/km, while that from October 2008 to 2009 are increased sharply to be 159,000m^3/km and 322,000m^3/km. Based on the erosion and deposition intensity evaluated by distance, after the impoundment of the Three Gorges Reservoir, the scouring intensity of Jingjiang Reach decreases gradually from the top to the bottom, and the scouring intensity of the oued channel and shoal channel of the upper Jingjiang Reach exceeds that of the lower Jingjiang Reach. From October 2002 to October 2014, the scouring intensity of shoal channel of the upper and lower Jingjiang reaches is 259.4m^3/km and 201.9m^3/km respectively, wherein during the impoundment of 135m, the upper section is less in scouring depth than the lower section and the scouring intensity of the upper and lower Jingjiang reaches is respectively 681,000m^3/km and 1,205,000m^3/km. During the impoundment of 156m, the shoal channel of the upper Jingjiang Reach is scoured by 248,000m^3/km, while the shoal channel of the lower Jingjiang Reach is deposited by 41,000m^3/km. After the impoundment of 175m, the shoal channel of the upper section is scoured much by 1,664,000m^3/km, while the shoal channel of the lower Jingjiang is scoured less by 829,000m^3/km.

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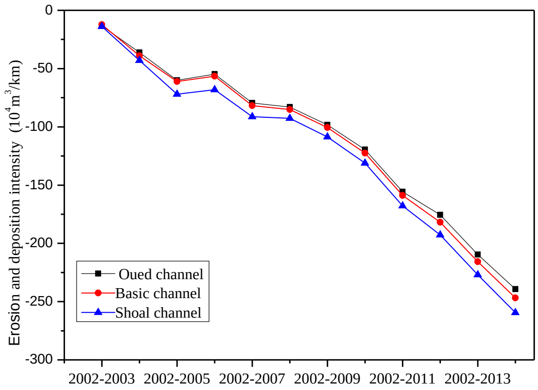

***Figure 2.** Accumulative erosion and deposition intensity of Upper Jingjiang*

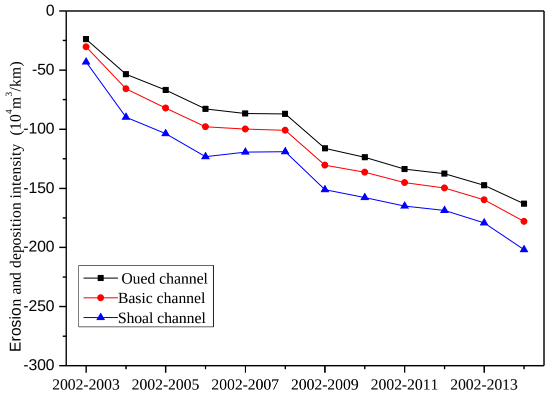

***Figure 3.** Accumulative erosion and deposition intensity of Lower Jingjiang*

Erosion and deposition adjustment law at different positions

After the operation of the Three Gorges, the erosion and deposition intensity of Jingjiang Channel riverbed has increased greatly. In terms of the scouring amount of oued channel and bottomland, the oued scouring amount of the upper Jingjiang reach from October 2002 to October 2014 takes up 92% of the scouring amount of the shoal channel, while the scouring amount of bottomland is 8% less than that of shoal channel. "Channel scouring" dominates in the upper Jingjiang reach after the operation of the Three Gorges and the oued channel plays the major role in riverbed scouring. The scouring amount of oued channel of the lower Jingjiang reach from October 2002 to October 2014 takes up 81% of the scouring amount of the shoal channel and the scouring amount of bottomland takes up 19% of that of the shoal channel. For the first 14 years after the operation of the Three Gorges, "bottomland and channel are scoured simultaneously", but the scouring amount of deep channel is far larger than that of the bottomland. Seen from the erosion and deposition process of each reach at different positions (see *Figure 4* and *Figure 5*), deposition occurs on the oued channel of the upper Jingjiang reach from October 2005 to October 2006 and it is in the scouring state in other time frames. The scouring mainly concentrated from October 2002 to October 2005 and from October 2008 to October 2014 in the state of "scouring of both bottomland and channel" and more than 90% of scouring occurs on the oued channel. The phenomenon of "channel scouring and bottomland deposition" occurs from October 2006 to October 2008 and the deposition amount of bottomland between the shoal channel and oued channel takes up more than 60% of the total scouring amount of oued channel. The scouring of the lower Jingjiang reach mainly concentrates from October 2002 to October 2006, from October 2008 to October 2009 and from October 2012 to October 2014, during all of which the riverbed is in the state of "scouring of both bottomland and channel" and the scouring amount of oued channel takes up more than 70% of the total. Different from the "scouring of both bottomland and channel" in the above time frames, the law of "channel scouring and bottomland deposition" occurs from October 2006 to October 2008 and from October 2009 to October 2012 and the deposition amount of bottomland above the oued channel accounts for more than 50% of the scouring amount of oued channel.

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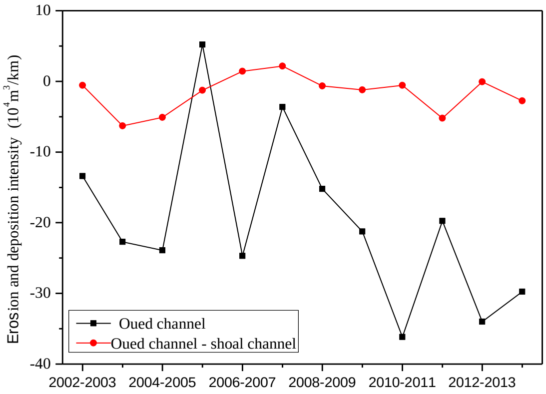

Figure 4. *Erosion and deposition intensity of the Upper Jingjiang*

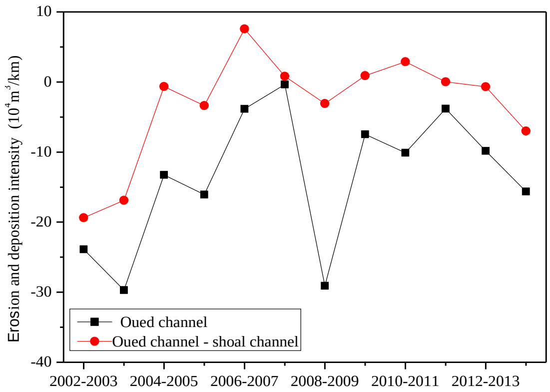

Figure 5. *Erosion and deposition intensity of the Lower Jingjiang*

Response to the upstream water change by riverbed erosion and deposition

After comparing the annual average runoff changing process of the main hydrologic stations in the middle reaches of Yangtze River before and after the impoundment of the Three Gorges Reservoir (*Figure 6*), each station experiences decrease first and then increase later as a whole in years. However, the annual average runoff from 2003 to 2014 is smaller than that before 2002 as a whole, wherein at the initial stage of impoundment from 2003 to 2007, except that the water volume of Jianli Station holds the line with that before impoundment, the multi-year average runoff of the rest stations for many years is 5-10% lower than that before impoundment. Compared with that from 2003 to 2007, multi-year average runoff at stations from 2008 to 2014 has a slight increase by 2% to 6%; compared with that before impoundment, except that it's 3.5% larger in Jianli Station (caused by that three exports of Jingjiang diversion ratio decreases so that discharge increases at the lower Jingjiang Reach), runoff in the rest stations is 3%-8% lower than that before impoundment. Because of adjustment of discharge flow by the impoundment of the Three Gorges Reservoir, annual runoff distribution and monthly runoff see obvious changes at stations, mainly presented as decreased discharge flow during the wet season, increased low flow, extended median water flow and that annual water flow distribution tends to be even entirely. After analysis on time distribution, the lowest flow period in a year is from January to March when the water content is only 7.5% of annual total water content before the impoundment of the Three Gorges Reservoir; after retaining water, with the constant acceleration of water level, low flow compensation adjustment in the Three Gorges Reservoir causes increases of low water flow to different degree in the downstream of the dam, especially the low water flow in Jingjiang Reach increasing significantly. In *Figure 7*, from Zhicheng Station to Jianli Station in Jingjiang Reach, the lowest water flow tends to increase stably along the flow because the shunt volume at diversion ports is zero during the lowest flow period; the average increasing rate is 36% from 2003 to 2007 compared with the time before 2002 and the average increasing rate is 40% from 2008 to 2014 compared with the time from 2003 to 2007. From Jianli Station to Hankou Station, the lowest water flow accelerates significantly due to tributaries confluence. On the whole, the lowest water flow from Yichang Station to Hankou Station increases year by year gradually due to the action of the Three Gorges; increase of low water flow can accelerate low flow erosion ability, so that simply from the perspective of

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hydrodynamic force changes, the overall scouring ability in Jingjiang Reach has increased after the impoundment of the Three Gorges Reservoir.

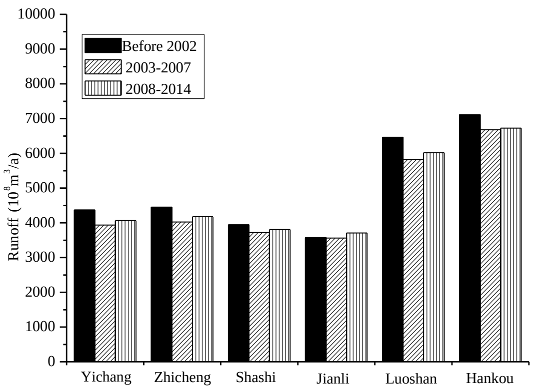

***Figure 6.** Changes of runoff in the middle reaches of Yangtze River*

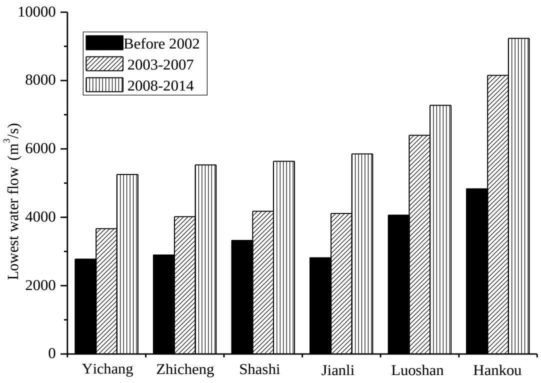

***Figure 7.** Changes of lowest water flow in the middle reaches of Yangtze River*

Response to the upstream sediment change by riverbed erosion and deposition

Changes of sediment runoff and median diameter

Before 2002, from 2003 to 2007 and from 2008 to 2014, changes of annual average sediment runoff in main hydrologic stations in the middle reaches of Yangtze River are shown in *Figure 8*. There are obvious differences among the periods before 2002, from 2003 to 2007 and from 2008 to 2014. Before 2002 when the Three Gorges was used for impoundment, multi-year average value of sediment runoff in the down stream of the dam has a decreasing trend along the flow from Yichang to Jianli and sediment runoff at each station has an increasing trend along the flow from Jianli to Hankou. After comparison with changes of runoff in *Figure 6*, it can be found that changes of sediment runoff are similar to changes of runoff along the flow, following law of large amount of sand accompanied with large amount of flow and small amount of sand accompanied with small amount of flow. After the impoundment of the Three Gorges Reservoir, affected by sediment retaining of reservoir, sediment runoff at each station has experienced sudden decrease. Sediment runoff are recovering because unsaturated sediment causes erosion along the flow, so sediment runoff at stations from Yichang to Hankou shows an increasing trend along the flow, while the total amount is still significantly lower than the multi-year average sediment runoff before retaining water. From 2003 to 2007, compared with sediment runoff before retaining water, a decrease from 62% to 87% is achieved. With the increase of water level in the reservoir, the sediment runoff at stations keeps decreasing; compared with that from 2003 to 2007, the sediment runoff from 2008 to 2014 decreases by 16% to 56%. From the perspective of overall change along the flow, impoundment in the reservoir causes the change of sediment runoff downstream and the closer to the dam, the more significant the influence is.

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Recovery of suspended sediment with different diameters and bed material compensation effect

Changes of suspended sediment median diameter at main hydrologic stations in the middle reaches of Yangtze River are shown in *Figure 9*. Because of impoundment in the reservoir, coarse sediment is intercepted in the reservoir and the median diameter of sediment becomes smaller after flowing out of the reservoir (Yichang Station) than that before impoundment. After the impoundment of the Three Gorges Reservoir, "discharge of clear water" occurs. Unsaturated sediment causes erosion in riverbed from the section near the dam; the coarse sediment as bed material is constantly rushed and lifted to supply suspended load sediment by the reservoir, while smaller sluicing material and fine sediment (d<0.125mm) are hard to be recovered by scouring so that the suspended sediment composition becomes coarser. As further development of scouring, the anti-erosion armoring layer formed on the surface of riverbed prevents further scouring and makes the suspended sediment composition finer. In addition, as the scouring and armoring layer advance to the lower reaches, the suspended sediment composition of the downstream dam reach successively completes the above process from coarsening to diminution. The median diameter of the suspended sediment at ZhiCheng Station is slightly decreased after impoundment, and that of Shashi Station, Jianli Station and Luoshan Station is increased respectively in different degrees, while that of Hankou Station has little change.

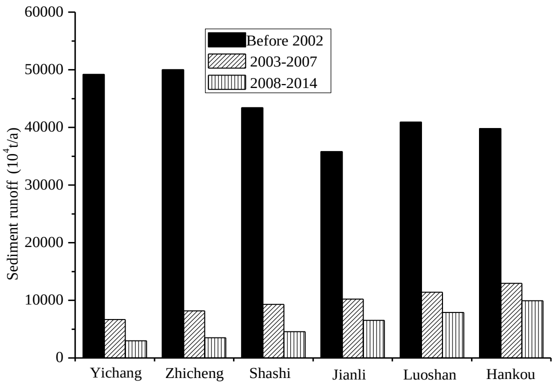

Figure 8. *Changes of sediment runoff in the middle reaches of Yangtze River*

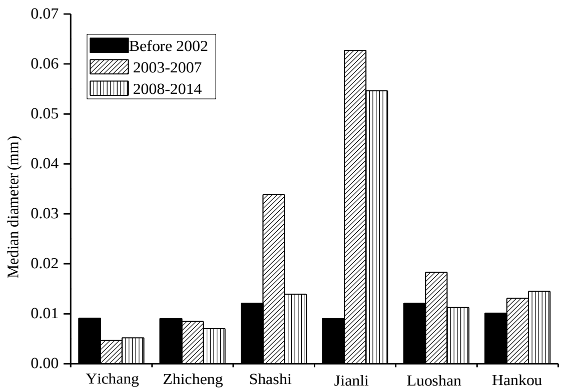

Figure 9. *Changes of suspended sediment median diameter in the middle reaches of Yangtze River*

Figure 10 is the measured bed material grading curve of Jingjiang Reach. Zhicheng Reach lies at the upper Jingjiang Reach and is a sandy gravel reach, in which, after the impoundment of the Three Gorges Reservoir the component particle with d<0.125mm is prone to decrease in the bed material and in 2010 it is nearly zero. The Ouchikou Reach and Jianli Reach are at the upper and lower Jingjiang reaches respectively, which are both sandy reach and after the impoundment of the Three Gorges, 90% of surface layer bed material particle diameter is within 0.125-1mm and therefore coarse sand with d>0.125m is the main component of the riverbed of Jingjiang Reach, which can be nearly considered that the bed material load is the suspended sediment above 0.125mm.

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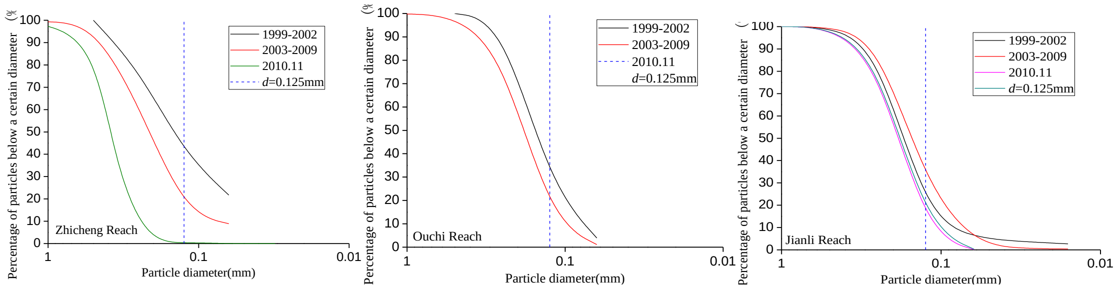

Figure 10. *Bed Material Grading Curve of Jingjiang*

Figure 11 is the variation of sediment runoff with d>0.125mm (coarse sediment) and d<0.125mm (fine sediment). For coarse particle suspended sediment along the river with d>0.125, as bounded from Jianli Station, suspended sediment runoff with d>0.125mm from Yichang Station to Jianli Station along the river increases, while that with d>0.125mm from Jianli Station to Hankou Station along the river decreases. From 2008 to 2014, the variation trend of sediment runoff with d>0.125mm is consistent with that from 2003 to 2007 in general, which indicates that from 2003 to 2014, the scouring impact caused by the impoundment of the Three Gorges mainly focuses on the reaches above Jianli Station and the riverbed coarsening advances to Shashi Station. *Figure 11* (b) indicates that runoff of suspended sediment with d<0.125mm from 2003 to 2007 and from 2008 to 2014 decreases significantly after the impoundment compared with that before, which is prone to increase from Yichang Station to Hankou Station, indicating that fine sediment with d<0.125mm is hard to be recovered after the impoundment of the Three Gorges Reservoir.

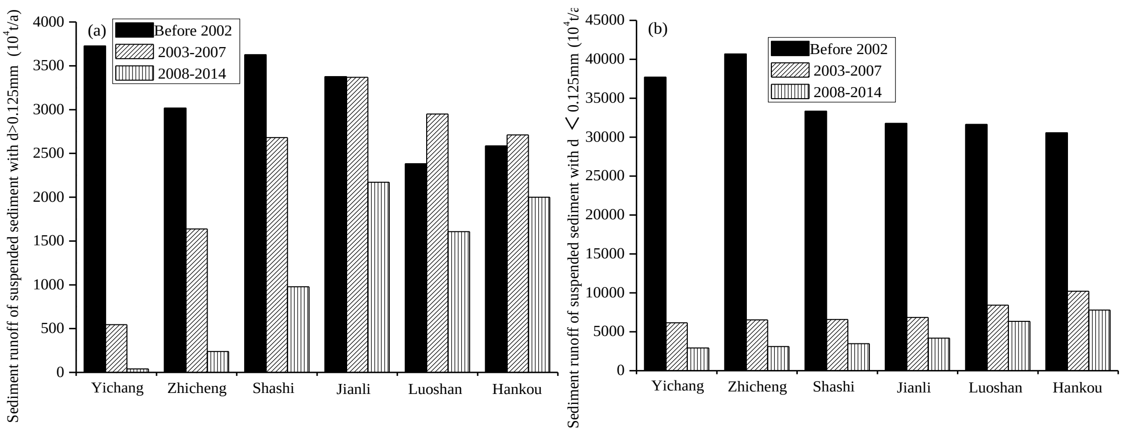

Figure 11. *Sediment runoff of suspended sediment in the middle reaches of Yangtze River*

Response of riverbed scouring to suspended sediment recovery and bed material compensation

Upper Jingjiang Reach lies between Zhijiang Station and Jianli Station, where the three Dongting Lake diversion outlets are also there and its diversion and confluence has minor impact on suspended sediment with d>0.125mm, while sediment recovery at the upper Jingjiang Reach along the river mainly comes from the scouring replenishment of riverbed material. As is shown in *Figure 10*, particle size of 99% of

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bed material in Ouchikou Reach is within 0.063-0.5mm, that is, bed material composition of upper Jingjiang Reach is relatively coarse, and with suspended sediment recovery along the river, massive coarse particle sediment with d>0.125mm is flushed, resulting in coarsening of suspended sediment along the river, which is evidenced by the gradual recovery of suspended sediment with d>0.125mm in upper Jingjiang Reach. Suspended sediment with d<0.125mm also gets recovered gradually, thus upper Jingjiang Reach is of "scouring of both coarse and fine sediment", which means that the upper Jingjiang Reach is a scouring concentrated reach after the impoundment of the Three Gorges Reservoir.

Lower Jingjiang Reach resides between Jianli Station and Luoshan Station, in which the median diameter of suspended sediment increases along the river, recovery of coarse sediment with d>0.125mm decreases and before 2002, from 2003 to 2007 and from 2008 to 2014, sediment runoff with d<0.125mm at Luoshan Station all is lower than that of Jianli Station; in other words, in these three sections, coarse sediment with d>0.125mm all presents deposition. In terms of d<0.125mm variation and in consideration of Chenglingji confluence between Jianli and Luoshan stations and taking suspended sediment runoff with d<0.125mm of Luoshan Station-Chenglingji Station-Jianli Station as erosion and deposition variation of the sediment composition of lower Jingjiang Reach, the d<0.125mm difference values for Luoshan Station-Chenglingji Station-Jianli Station before 2002, from 2003 to 2007 and from 2008 to 2014 are 2600×104t/a, 150×104t/a and 60×104t/a respectively, which means that it is a deposition trend before impoundment, while a scouring trend after impoundment. On the whole, lower Jingjiang Reach presents "deposition of both coarse and fine sediment" before the impoundment of the Three Gorges Reservoir and presents "coarse sediment deposition and fine sediment scouring" after the impoundment. However, given suspended sediment caused the impoundment of the Three Gorges Reservoir has been recovered to downstream Jingjiang Reach and bed material composition is relatively fine (in *Figure 10*, 99% of bed material particle size at Jianli Reach is within 0.016-0.3mm), sediment exchange mainly presents the constant exchange between coarse particle sediment in suspended sediment and the relatively fine sediment in bed material, which is exactly the phenomenon of "coarse sediment deposition and fine sediment scouring".

Discussion on riverbed erosion and deposition trend

After the performance of the Three Gorges Reservoir for impoundment, the dam intercepts massive sediment, with few discharge of sediment, and the average value of d_{50} for the first 30 years is lower than 0.01mm, which can be considered as discharge of clear water. Clear water discharge causes the downstream dam reach under the unsaturated condition in the long term and further causes the sediment concentration in the downstream dam to recover gradually, with long-distance erosion from top to bottom over time. Seen from riverbed composition, and specific to Jingjiang River dam-side sandy gravel reach, fine sediment is almost fully scoured and the runoff intensity of coarse sediment, especially the sandy gravel, will be decreased as a result of flow process variation; meanwhile, upper-layer sandy gravel plays a role of concealing and protection to the lower-layer riverbed, which strengthens the anti- scouring intensity of the riverbed. According to scouring simulation calculation results from Wuhan University, after 20 years of the impoundment of the Three Gorges Reservoir, the

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riverbed erosion of the reach between Zhijiang and Jiangkou will basically come to an end. For the sandy reach of Jingjiang River, fine sand with d<0.1mm is an important component of dam discharge flow sediment, and it's limited in riverbed composition, which is exchanged in the term of "coarse sediment deposition and fine suspension" in the riverbed erosion process and has limited the suspended sediment recovery of such particle size in the water. The content of coarse sediment with d>0.1mm is extremely few in the Three Gorges Dam discharged water, but it is considerably existing in the riverbed of Jingjiang Reach where the sediment can recover rapidly through riverbed replenishment and over time the main scoured reach transfers from upper Jingjiang Reach to lower Jingjiang Reach. After the successive application of a series of hydropower projects such as Xiangjia Dam and Xiluodu reservoir at the lower reaches of the Three Gorges, the discharge of clear water will be intensified further, and it is estimated that the dam discharged sediment of the Three Gorges after these upstream projects are implemented will be reduced by at least 35% where, the sediment grading will be finer, coarse sediment with d>0.1mm discharged will be less and sediment of such particle size will be the main component of Jingjiang Reach riverbed composition. In order to recover coarse sand with d>0.1mm in the suspended sediment, Jingjiang Reach, especially lower Jingjiang will still be under continuous scouring. *Figure 12* shows the erosion and deposition variation of upper and lower Jingjiang reaches after reservoir is established at the upper reaches of Three Gorges Reservoir.

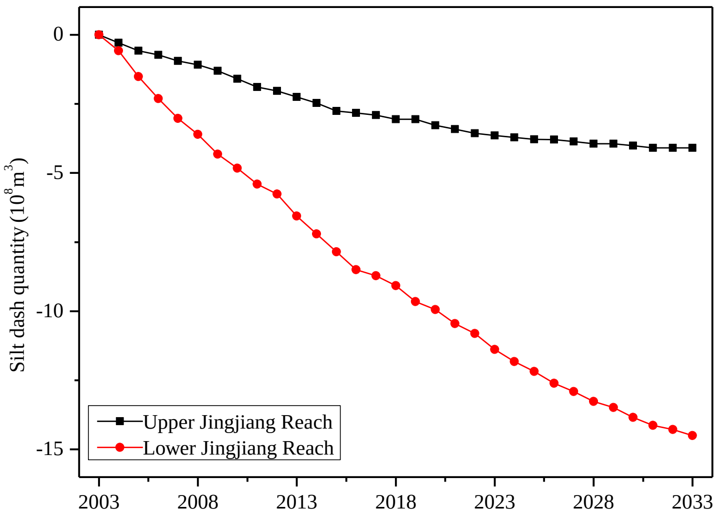

Figure 12. *Erosion and deposition trend of Jingjiang Reach*

Conclusion

On the basis of the hydrological sediment materials before 2002 and from 2003 to 2007 and from 2008 to 2014 from major hydrologic stations of Yangtze River, as well as actually measured topographical data of Jingjiang Reach before and after the impoundment of the Three Gorges Reservoir, this article has analyzed the response of erosion and deposition of Jingjiang riverbed to flow changes and sediment change, discussion the riverbed erosion and deposition trend. Main conclusions are as follows:

(1) After the impoundment of the Three Gorges Reservoir, the annual average runoff variation at the downstream dam is minor and the regulation of impoundment of the Dam influences the allocation of runoff in a year, where low flow increases, especially

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from 2008 to 2014. Judging from the hydrodynamic force variations, the integral scouring capacity of Jingjiang Reach, especially low flow scouring capacity, increases.

(2) After the impoundment of the Three Gorges Reservoir, sediment runoff for various stations downstream to the dam have reduced significantly compared with that before and the total volume is apparently lower as well though it recovers along the river gradually. The recovery of coarse sand with d>0.125mm mainly comes from watercourse replenishment and the sediment of this component up to Jianli Station from 2003 to 2007 has been recovered or even exceeded that before the impoundment, while the recovery from 2008 to 2014 fails to reach the level as before. Fine sand with d<0.125mm is greatly decreased after the impoundment and cannot be recovered through scouring.

(3) After the impoundment of the Three Gorges Reservoir, the erosion and deposition characteristics of sediment with d>0.125mm (coarse) and d<0.125mm (fine) are distinctly different in upper and lower Jingjiang reaches. Sediment with d>0.125mm and d<0.125mm in upper Jingjiang Reach has gradually recovered and that of upper Jingjiang Reach presents "scouring of both coarse and fine sediment". Water flow saturability of lower Jingjiang Reach has recovered significantly, and recovery velocity of coarse sand with d>0.125mm decreases, while fine sand with d<0.125mm still recovers along the river and the lower Jingjiang Reach presents "coarse sediment deposition and fine sediment scouring" after the impoundment.

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