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Sediment transport from the Yangtze River, China, into the sea over the Post-Three Gorge Dam Period: A discussion

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Abstract

Sediment loads from the Yangtze River into the sea experienced a major increase in the late Holocene when sand beaches along the deltaic coast changed into tidal-flats. Sediment transport averaged about 472 million tons a year between the 1950s and the mid-1980s and decreased by 124 million tons a year after the mid-1980s, followed by a dramatic drop since the closure of the Three Gorge Dam (TGD). This paper discusses the major processes for the decline of sediment discharge since the 1950s and discusses the method for evaluating its future development over the Post-TGD Period. Sediment loads in the Post-TGD Period will be mainly determined by the major processes that may significantly contribute to the following three components, i.e. (1) the sediment input from the upper basin into the Three-Gorge Reservoir (TGR); (2) the ratio of sediment export from the TGR relative to the input and (3) the amount of sediment recovery downstream the TGD restrained by available sediment sources. An integrated evaluation shows that the annual sediment loads over the Post-TGD Period will possibly vary from 1.12 to 1.32 million tons a year or less in ordinary years.
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1. Introduction

Sediment transport from large rivers plays an important part in geological, biological and chemical processes on the earth surface. The Yangtze River is one of the largest rivers in the world, both in terms of its spatial scale and its mass transport including water, sediment and other important elements for global changes.

The signal of long-term changes in sediment loads from the Yangtze River into the sea may be traced back to the recent geologic history. The Yangtze River delta today is characterized by muddy coast due to a rich sediment supply from the drainage basin. However, it was characterized by sand beaches in mid-Holocene when a series of chenier-like sedimentary bodies developed along the coast. This phenomenon reflects a lower sediment loads from the Yangtze River to its deltaic coast. Both the geological and archaeological evidence indicated that it was only after about 2000–1500 years BP that the Yangtze River began to build its delta rapidly (Tan, 1973; Liu and Walker, 1989). In addition to a lesser sediment supply from the Yangtze River during this period, Chen (1996) also attributed this phenomenon to the process of riverbed aggradation in response to the rapid post-glacial sea-level rise.

The study on human impacts on sediment discharge from the Yangtze River into the sea began earlier in the 1990s. Chen (1996) found that there is no significant trend in the long-term changes of sediment discharge by the mid-1980s. The human activities had dual effects on the sediment discharge into the sea. They contributed considerably more sediment by intensifying the erosion processes on the land surface, while greatly reducing the sediment supply from tributaries by constructing a large number of reservoirs that function as sediment traps (Chen, 1996). A series of studies were conducted on the sediment yields in the upper Yangtze River (e.g. Yu, 1987; Lu and Higgitt, 1999). Meanwhile, there were already academic concerns about the deltaic development and coastal erosion during the Post-Three Gorge Dam (Post-TGD) Period (Chen and Zong, 1998).

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Since the beginning of the 21st century there have been a series of publications on the changes of and causes for the sediment discharge from the Yangtze River (MWRC, 2001; Yang and Xiong, 2002; Yang et al., 2002, 2006a; Fu et al., 2003, 2006; Chen et al., 2005; Wang et al., 2007). Several studies investigated sediment yield and sediment delivery from the upper basin that has improved understanding of the sediment decline in recent decades (Higgitt and Lu, 2001; Lu and Higgitt, 2001). In addition to the sediment diversion from the main Yangtze River that greatly increased sedimentation in Dongting Lake (Shi et al., 1999), other important land-surface processes in the mid-lower basin have also received attention, such as the sedimentation processes in more than 30,000 reservoirs (Chen et al., 2006a) and the in-channel sand extraction from the mid-lower Yangtze River (Chen, 2004; Chen et al., 2005, 2006b). In-channel sand extraction from the mid-lower Yangtze River has also significantly reduced the sediment transport from the Yangtze River into the sea. There are controversies about the amount of sediment recovery downstream of the TGD since the 1980s. Xu (1987) and Chen and Zong (1998) proposed that the available sediment source may be a limiting factor for sediment recovery downstream of the dam. In contrast, Yang et al. (2007) insisted that ‘‘sediment availability downstream of the TGD will not be a limiting factor’’.

Several papers since this century tried to quantitatively predict the sediment discharges over the coming decades and even for the coming century (Yang et al., 2003, 2006b, 2007). However, these predictions all appear to over-estimate the sediment discharge in the coming decades and the next 100 years. It is obvious that from the present state-of-art and the available data source, more scientific studies should be directed to the major processes that determine the sediment supply, transport and deposition in the river system.

2. Geographical background

The Yangtze (Changjiang) River extends over 6300 km from its headwaters in the Qinghai-Tibet Plateau to East China Sea. Its drainage basin covers about 1.80×10^6 km^2 in area (Fig. 1), with a human population of about 427 million in 2000. The Yangtze River transports about 900 billion m^3 of water into the sea each year and carried about 434×10^6 tons of sediment in the Pre-TGD Period from 1953 to 2000. Most sediment transportation (about 87%) takes place in summer-half year from May to October. The river is generally divided into two parts: the upper Yangtze River, and the mid-lower Yangtze River, between the two gauging stations at Yichang and Datong. The estuarine reach of the Yangtze River extends 680 km from Datong (tidal limit) to the river mouth.

The upper basin covers about 1.0 million km^2. The headwater area is located in the Tibet Plateau upstream from Yushu, generally over 4500 m above sea-level. The main Yangtze River from Yushu to Yibing is termed ‘‘the Jinsha River (the gold-sands river), where the landscapes are characterized by high mountains and deep valleys. The mountain chains in this region trend NNW-SSE. These landforms block surface transportation from east to west, and influence moisture transport from the Bay of Bengal to

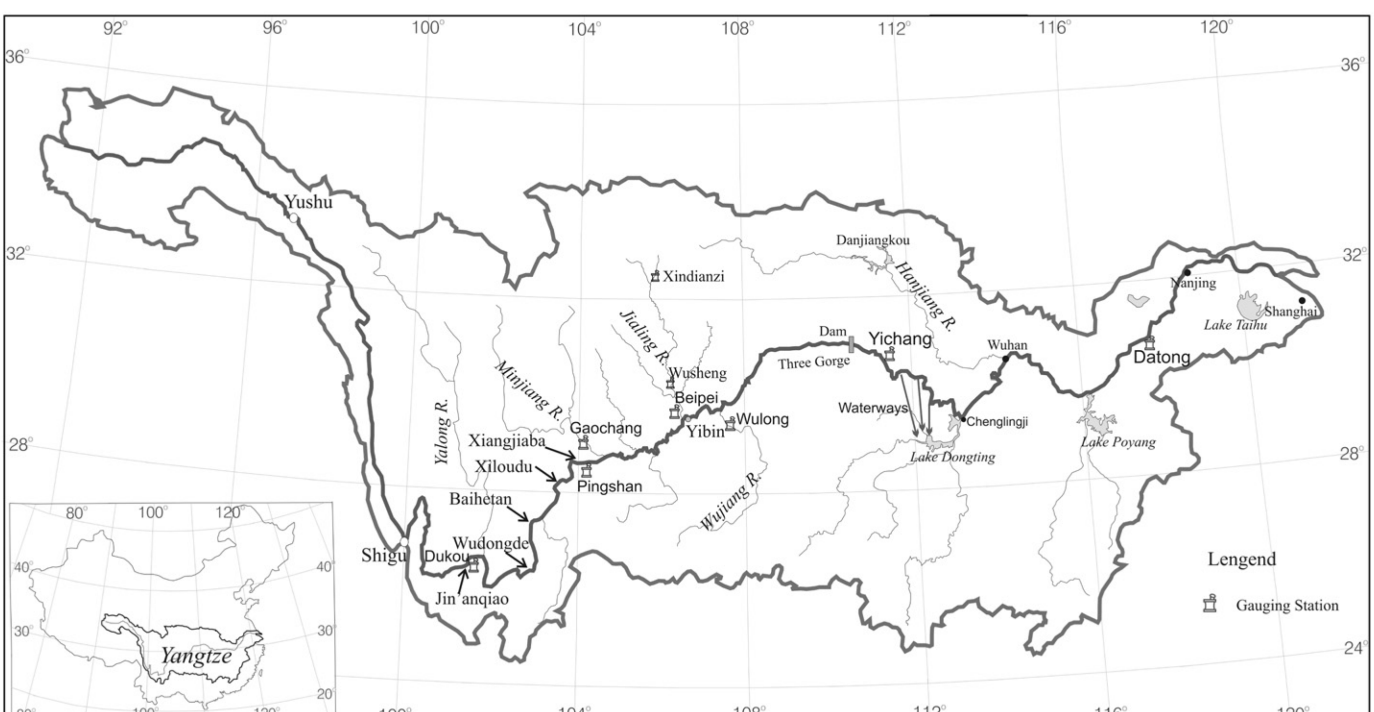

Fig. 1. Geographical setting of the Yangtze River and its watershed.

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