Physics and Chemistry of the Earth 47–48 (2012) 76–85

Contents lists available at ScienceDirect

Physics and Chemistry of the Earth

journal homepage: www.elsevier.com/locate/pce

Water abstraction along the lower Yangtze River, China, and its impact on water discharge into the estuary

Erfeng Zhang [a,b,*], Hubert H.G. Savenije [b], Shenliang Chen [a], Jiyu Chen [a]

[a] State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai, China
[b] Department of Water Management, Delft University of Technology, Delft, The Netherlands

ARTICLE INFO

Article history:
Received 13 January 2010
Received in revised form 25 April 2011
Accepted 7 May 2011
Available online 15 May 2011

Keywords:
Water abstraction
Water diversion project
Water discharge into the estuary
Three Gorges Reservoir
Lower Yangtze River downstream from Datong

ABSTRACT

The impact of human activities on river discharge has become a worldwide issue due to rapid developments. In recent years, water abstraction along the lower Yangtze River downstream from Datong has received much attention due to the increase of salt intrusion in the estuary. This study has been conducted to estimate the water abstraction and drainage along the lower Yangtze River for the critical period between September and April, identify their spatial differences and temporal variations, and analyze their impact on water discharge into the estuary. The results show that the drainage is dominant in the upper portion, and does not follow any obvious pattern. However, the water abstraction mainly occurs in the lower portion, and follows set patterns in daily variation according to the tidal situation and the seasonal variation corresponding with the water demands. They have both increased in recent similar hydrological years due to rapid developments. The water abstraction decreases the discharge into the estuary in dry years or dry periods, most dramatically during spring tide. The highest impact occurs between January and March of a dry year. After the commissioning of the Three Gorges Reservoir (TGR), this impact increased in October and November due to its filling, more so when a drought occurs in the upper and middle basin. However, the reverse applies between January and April owing to the increase of its outflow. In the future, the water abstraction will continue to increase in the same hydrological years, possibly increasing problems with salt intrusion in the Yangtze Estuary.

1. Introduction

Due to economic development and population growth, and ultimately the rising demand for water resources, the water discharge of many rivers worldwide has changed as a result of damming and water abstraction. These anthropogenic disturbances are the main factors inducing the decrease in water discharge of many rivers such as the Indus, Rio Bravo/Rio Grande, Krishna, Ganges, Syr-Darya, Amu-Darya, Colorado, Nile, and the Yellow Rivers (Goudie, 2000; Johnson et al., 2001; Cohen and Henges-Jeck, 2001; Gleick, 2003; Mirza, 2004; Milly et al., 2005; Wang et al., 2006a; Milliman et al., 2008; Kundzewicz et al., 2009; Ludwig et al., 2009), which may result in severe side-effects and the degradation of the environment and ecosystem in deltas.

The lower Yangtze River downstream from Datong flows through Anhui and Jiangsu provinces before entering the estuary at Xuliujing (Fig. 1). Datong is the last permanent hydrometric station with long discharge records in the main Yangtze River, located at the tidal limit of the Yangtze Estuary. Downstream from this point, there is no large tributary, and the discharge is difficult to observe owing to the tidal influence. Thus, the discharge at Datong is commonly regarded as the discharge into the estuary. However, Datong is situated approximately over 500 km away from the estuary, and the region along the lower Yangtze River is one of the most developed areas in China, containing 9 cities and 13 counties with much water consumption. The water level in this reach is under the influence of the tide, which provides favourable conditions for water transfer from the Yangtze River to its tributaries during flood tide. Since the 1950s, many sluices and pumping stations have been constructed at the mouth of these tributaries to control water abstraction and drainage, particularly in Jiangsu province. Due to rapid economic development, the demand for water resources has increased greatly in recent years. Currently, not only irrigation water but also domestic water and industrial water are extracted from the Yangtze River in all of these cities and counties. Because of serious pollution in the tributaries much water is abstracted for improving water quality as well. In addition, the Northern and Eastern Jiangsu in the Huaihe River basin and the Taihu Lake also get water from the Yangtze by water transfer projects. The present facilities for water abstraction in this region are more than 300 in number. These interventions have become the

* Corresponding author. Tel.: +86 21 62231028; fax: +86 21 62546441.
E-mail address: efzhang@sklec.ecnu.edu.cn (E.F. Zhang).

1474-7065/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.pce.2011.05.002

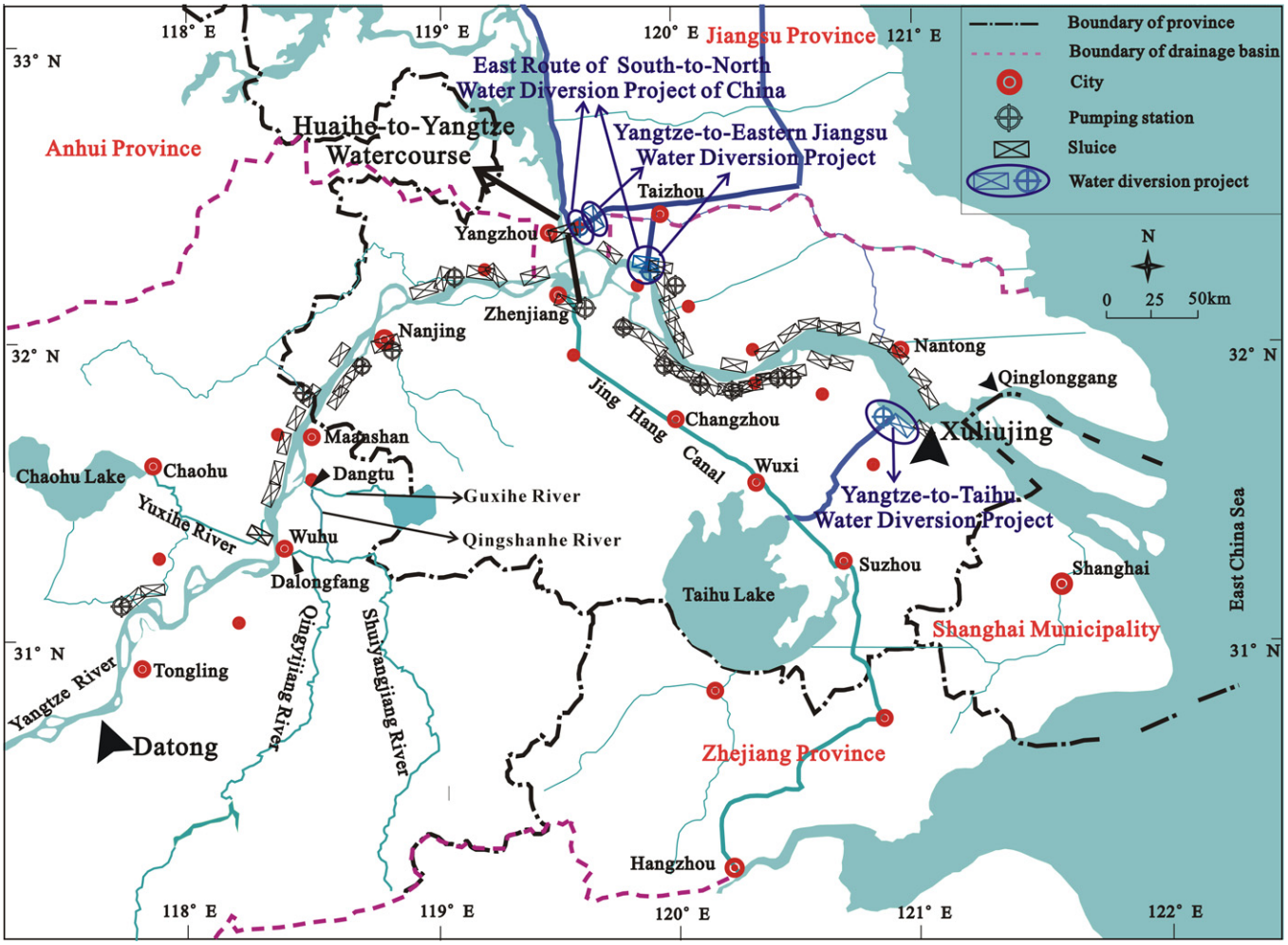

Fig. 1. The lower Yangtze River basin downstream from Datong (the large and middle sluices and pumping stations are shown).

most important reason for changes in the discharge regime of the lower Yangtze River.

The Yangtze River, the largest river in China, discharges a huge volume of water from the upper and middle reach, with a mean annual discharge of approximately 28,310 m^3/s at Datong (Fig. 2A). However its discharge shows large seasonal and annual variation (Fig. 2B). The mean monthly discharge between 1950 and 2009 was on average 16,600 m^3/s during the dry season (from November to April) and 39,800 m^3/s during the flood season, with its minimum of 11,100 m^3/s in January and its maximum of 49,700 m^3/s in July. The recorded monthly mean and daily discharge ranges from 6730 m^3/s (February 1963) to 84,200 m^3/s (August 1954), and from 4620 m^3/s (on 31 January 1979) to 92,600 m^3/s (on 1 August 1954), respectively. Additionally, affected by human activities and climate change in recent years, it is anticipated that the discharge during the flood season could also decrease substantially. For example, in September and October 2006 and October 2009 the monthly mean discharge was only 18,900 m^3/s, 15,000 m^3/s, and 17,400 m^3/s respectively, which became the historical minima for these months in 2006 and was close to the minimum in 2009, with values similar to the dry season discharge (Fig. 2B). Besides the droughts occurred in the upper and middle basin, particularly

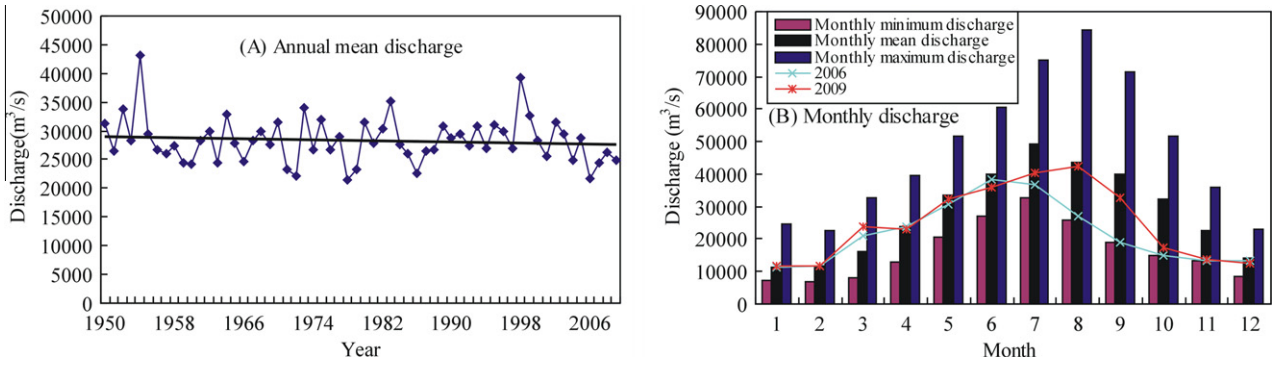

Fig. 2. Water discharge at Datong hydrometric station.