COMMENTARY

Impacts of the middle route of South to North Water Transfer Project on water environment in China

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The large hydraulic engineering has become one of the most important influences on water environment among many human activities which change the river greatly. During the last 100 years, more than 47,000 large and 800,000 small dams have been built around the world[1–4], with China accounting for a large proportion. According to the *2013 Statistics Bulletin on China Water Activities*, 97,721 reservoirs were constructed in China. Although hydraulic engineering provides various benefits such as water supply, irrigation, hydroelectric power, flood protection and recreational opportunities[5], it has detrimental effects on river morphology, function and water environments. Typically, the downstream impact of large hydraulic engineering is well documented. For example, the Three Gorges Dam across the Yangtze River in China, the largest hydropower project in the world, has been changing the flow pattern, channel morphology and sediment transport as well as ecological processes, which may cause water environment degradation in the middle and downstream reaches of rivers and lakes[6]. Large hydraulic engineering also tends to increase water residence time and change the concentration of nitrogen and phosphorus[7]. As a consequence, the flow velocity and water environment capacity will decrease and the concentration of nitrogen and phosphorus in water will increase. Therefore, large hydraulic engineering can create a water environment that is advantageous for algae and other aquatic organisms[8], but causes environmental problems such as algal blooms and outbreaks of water hyacinth.

The Three Gorges Dam, completed in 2009, has attracted public attention, and a heated discussion on whether it was necessary to build such a dam. Hence, it is time to summarize the impacts on the downstream of the Yangtze River. The *Bulletin on the Ecological and Environmental Monitoring Results of the Three Gorges Project* (*2008–2013*) showed that the coverage of water eutrophication has increased from 25.6% to 37.7% in the Yangtze River and its tributaries since the Three Gorges Dam was completed. The number of tributaries experiencing algal blooms or outbreaks of water hyacinth has increased from 7 to 22 during this period. According to Xiong *et al.*[9], the increased coverage of water eutrophication threatened the drinking water security in the Three Gorges Dam regions and some other tributaries of the Yangtze River.

Similarly, water eutrophication appeared in the middle and downstream regions of Hanjiang River – the longest tributary of the Yangtze River. From August to October in 2015, water hyacinth occupied a large area of the Wuhan section of Hanjiang River, Qingshan Lake and Jinshui River. The local government sent salvage ships to remove the phytoplankton, but it was a difficult task because of the large area[10–12]. Compared to 2014, the algal blooms and outbreaks of water hyacinth were more in 2015, with earlier outbreak time, longer persistence time and wider scope of influence. The outbreak time was from May to October in 2014, but it advanced to February in 2015. The total coverage also increased. There are many reasons for this, such as natural environmental conditions, emission of pollutants, and particularly, hydraulic engineering, which is one of the main elements controlling water quality and causing water eutrophication in the middle and downstream regions of the Hanjiang River.

Driven by the growth of population and water demand, conflicts between water environmental protection in the water-exporting areas and its demand in the water-importing areas have become increasingly intense. The middle route of the South to North Water Diversion Project (SNWDP) has been highly controversial for decades, and the debate has become more intense during recent years. The middle route project focuses on solving the problems of domestic and industrial water in northern China, such as Hebei, Henan, Beijing, etc. The water system has officially worked in December 2014 (ref. 13). There is no doubt that the middle route of SNWDP can bridge the gap between water supply and demand in the northern urban areas, which may benefit about 100 million people. However, the middle route project has major influence on the activities of water withdrawal and ecological environment in the protected water source areas as well as the downstream regions. The middle and downstream regions of the Hanjiang River are major grain-producing areas and urbanized areas. They play an important role in ensuring food security and in boosting the economic development; for example, the Hubei Province itself accounted for 4.28% in total national GDP based on *2014 Statistical Yearbook of Hubei Province*. Whereas the middle route project reduces the discharge volume of the Danjiangkou Reservoir, since 95 billion cubic metres of water is extracted every year, which will reduce the water environmental capacity and water flow velocity in the middle and downstream of Hanjiang River and increase the probability of the outbreak of algal bloom. What's more, the problem would be worse after completing the second-stage construction of the middle route project in 2030 (ref. 14). Furthermore, the water eutrophication problem has became more severe in the downstream regions of the Hanjiang River since the height of the dam of the Danjiangkou Reservoir was increased in 2005 to impound water. At least six events of algal blooms have occurred in the recent ten years, mostly during 2011–2015; now the problem has worsened. Thus, the water diversion project which consists of a series of hydraulic structures is one of the factors that induces overgrowth of phytoplankton. On the other hand, phytoplankton death increases in negative oxygen environment. Therefore, the engineering and non-engineering measures are urgently necessary to be taken into account to relieve the water environment crisis.

At present, 'ecological civilization construction' is a high priority item in water resource management system in China[15] to realize the sustainable development of water resources which can promote the socio-economic development. In order to effectively improve water quality in the middle and downstream

regions of the Hanjiang River, the quantity of pollutants discharged needs to be controlled. The role of the government in water environmental protection should be first clarified. Relevant supervision and management should be strengthened to have strict control on sewage discharge from industries. All of these aim to reduce the total pollutants discharged and the quantity of nitrogen and phosphorus in water. Secondly, the investment on water environmental protection should be accelerated to implement dynamic monitoring and early warning of sewage discharge. When the water eutrophication condition worsens, river management activities should be adopted to prevent algal blooms. At the same time, reservoir operation should be strengthened. The discharge volume should be ensured to control the reproduction and growth of phytoplankton during algal blooms. Finally, public supervision should be intensified, and tip-offs from the public should be encouraged in the form of financial rewards to promote awareness among the public to protect water environment and ensure water safety.

1. Cailin, H. O., *Environ. Practice*, 2001, **3**(3), 191–192.
2. Rosenberg, D. M., McCully, P. and Pringle, C. M., *BioScience*, 2000, **50**(9), 746–751.
3. Richter, B. D. and Thomas, G. A., *Ecol. Soc.*, 2007, **12**(1), 1–26.
4. Haghighi, A. T., Marttila, H. and Klove, B., *Global Planet. Change*, 2014, **122**, 186–196.
5. Skalak, K. J., Benthem, A. J., Schenk, E. R., Hupp, C. R., Galloway, J. M., Nustad, R. A. and Wiche, G. J., *Anthropocene*, 2013, **2**, 51–64.
6. Wu, H. P. *et al.*, *Ecol. Eng.*, 2013, **57**, 72–78.
7. Suwarno, D., Löhr, A., Kroeze, C., Widianarko, B. and Strokal, M., *Sustain. Water Qual. Ecol.*, 2014, **3–4**, 55–66.
8. Martins, I., Pardal, M. A., Lillebo, A. I., Flindt, M. R. and Marques, J. C., *Estuarine, Coast. Shelf Sci.*, 2001, **52**(2), 165–177.
9. Xiong, C. J., Liu, D. F., Zheng, B. H., Zhang, J. L., Hu, N. S., Zhang, Y. and Chen, Y., *Appl. Mech. Mater.*, 2013, **295–298**, 1981–1990.
10. *China Daily*; http://www.chinadaily.com.cn/china/2015-08/28/content_21729668.htm (accessed on 28 August 2015).
11. *China News*; http://www.chinanews.com/tp/hd2011/2015/09-23/565917.shtml (accessed on 22 September 2015).
12. *Chutian Metropolis Daily*; http://news.cnhubei.com/xw/wuhan/201510/t34153-95.shtml (accessed on 15 October 2015).
13. *Xinhua News*; http://news.xinhuanet.com/english/photo/2014-12/12/c_13385-1175.htm (accessed on 12 December 2014).
14. Dou, M., *J. Hydraul. Eng.*, 2005, **36**(6), 727–732.
15. Hu, Y. J., *Appl. Mech. Mater.*, 2014, **522–524**, 1810–1816.

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