COMMENTARY

The role of wetland in water quality purification and maintenance of coastal reservoirs: a case of Qingcaosha Reservoir

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Abstract: Qingcaosha Reservoir (QR) is typical fresh water storage and salty water avoidance featured coastal reservoir, which is located in south branch of Yangtze River Estuary, China. Due to the location of QR, pollutants and short-term salt tides have threatened the clean fresh water intake of the reservoir. There are 289 km^2 shoal wetlands in upstream of QR. After the continuous purification of wetlands, water quality of raw water has been improved. Qingcaosha shoal, Zhongyangsha shoal, Beixiaohong shoal and Dongbeixiaohong shoal are on the circumference. From the water quality monitoring data after the reservoir operation, the average value of NH_4^+-N, NO_3^--N, TN, TP in the outlet are 81%, 65%, 77% and 66% of the inlet respectively after flowing through the natural wetland in the reservoir. The wetlands can solve two major problems facing the coastal zone reservoirs that enhance intake water quality and stabilize water quality. In the design of coastal reservoirs, we suggest that we should make the full use of existing wetlands, enhance the function of wetland water purification through ecological engineering methods, and construct artificial wetlands as a supplement.
Keywords: coastal reservoir, salt tide, wetland, water purification

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1 Introduction

Water is widely regarded as the most essential natural resources, yet freshwater systems are directly threatened by human activities [1]. Raw water, which includes rainwater, ground water, and water from bodies like lakes and rivers, is now severely contaminated due to the prosperous economy and industry in developing countries [2]. It is urgent to seek alternative water sources to full the increasing demand of good quality water. Therefore, many countries have built artificial reservoirs to support drinking water treatment plants. A Coastal Reservoir is a freshwater reservoir located in the sea at the mouth of a river with a sustainable annual river flow [3].

Coastal reservoirs are generally built in economically developed and densely populated areas. Pollution load poses a serious challenge to the water quality of the reservoir. As a kind of fresh water storage and salty water avoidance featured reservoir, coastal reservoir is open to intake water under context of fresh water, and closed to save water under context of salty tide. This is good to cut the peak and valley in time dimension. However, this leads to increased risk of pollution loads during water storage stage, and potential of algal bloom because of hydrodynamic reduction during reservoir close stage.

Figure 1. The location of Qingcaosha Reservoir.

To take clean water and maintain good water quality during salty tide is the challenge facing the coastal reservoir, This paper would like to discuss that how Qingcaosha Reservoir (QR) which is a typical coastal reservoir to solve the problems.

2 Location of Qingcaosha Reservoir

Qingcaosha Reservoir is located in South Branch of Yangtse River Estuary, the north to Changxing Island, north east of Shanghai (31°27'N, 121°38'E). It is now the drinking water source for over 11 million people in Shanghai (designed water supply volume of 7.2×10^6 m^3/day). The QR has a surface area of 66 km^2, a volume of 4.35×10^8 m^3, and the depth ranges from 1.5-7.1 m. It receives a regular fresh water supply from the Changjiang River, and was designed to prevent the ocean tide from the East China Sea. The incoming fresh water flows through the reservoir from the west (inlet sluice) to the east (pump station), and is finally pumped and distributed to 8 drinking water treatment plants in Shanghai. The hydraulic retention time (HRT) is in the range of 15-35 days. A constant-closed outlet sluice was set to discharge excess water.

3 Water Quality Challenges to Qingcaosha Reservoir

The Yangtze River Delta area, as well as the Yangtze watershed is the most important industrial and agriculture center in China. Small enterprises in the Yangtze River Delta, such as textile companies, chemical plants, paint factories, and food production factories, make a significant contribution to the areas rapid economic growth. The consumption of water from these industries has led to increased water shortages in certain parts of the delta. Moreover, due to the lack of efficient waste treatment facilities and the scattered distribution of these small enterprises, water pollution has become a serious problem. In 2005, for example, the discharge of industrial wastewater and domestic sewage was over 63,109 tons, and only 40% of it was treated[4]. This does not include drainage water from agricultural fields and urban runoff, as well as imported pollution from upstream areas of the delta. Aquaculture itself is another significant source of pollution, with nitrogen (N) and phosphorus (P) from manure and feed as important pollutants[5].

Due to the location of QR, there are two major sources of salt tide that affect the concentration of chloride in their waters, one is the northern tide from north branch of Yangtze Estuary, and the other is the direct intrusion of saltwater from the East China Sea. When the chloride concentration is more than 250 mg/L the reservoir will stop taking water. According to the design of the reservoir, the maximum number of consecutive days without water is 68 days[6].

4 Wetlands in the Upstream of QR

The Yangtze River runs into the estuary area and flows through wetlands to the QR, and the wetlands include Baimomaosha shoal, Dongfengxisha Shoal, Shangbiandan Shoal, Xiabiandan Shoal *et al*[7]. (Figure 1 and Figure 2). The total area of the shoals is 289 km^2. The vegetation in the wetland is mainly composed of Phragmites australis community, Zizania latifolia community, Scripus triqueter community, Spartina alterniflora community and bare flat. Different vegetation types of wetland in the Yangtze Estuary have capacity on N and P removal in Table 1.

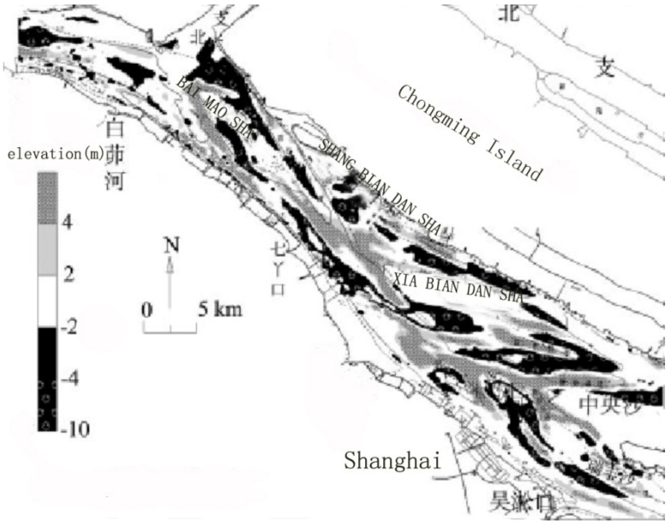

Figure 2. Shaols distributed upstream of QR.

Table 1. Nitrogen (N) and phosphorus (P) removal capacity of different vegetation type of wetland in the Yangtze Estuary.

Vegetation types	N and P remove capacity (t/km²/a)	
	N	P
Phragmites australis community	8.69 - 39.62	0.58 - 2.64
Spartina alterniflora community	14.99 - 36.68	1.54 - 3.93
Scripus triqueter community	1.47 - 12.34	0.21 - 1.75
Bare flat	0.04	0.004

After the continuous purification of wetlands, water quality in the QR water intake has been improved. (Figure 3 compares the water quality monitoring data of the Xuliujing water quality monitoring section and the reservoir water intake, and the contents of the main nutrient indicators (TN and TP) are significantly reduced[9].

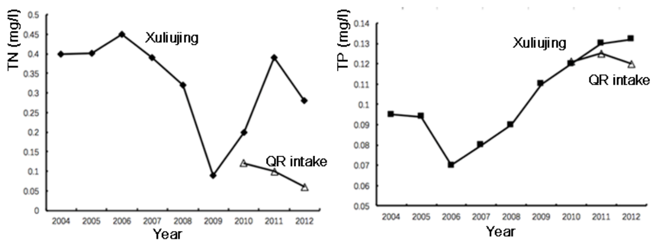

Figure 3. Comparison of the water quality monitoring data (TN and TP) between Xuliujing section and the reservoir water intake section in Yangtze River.

5 Wetlands in QR

In QR, Qingcaosha shoal, Zhongyangsha shoal, Beixiaohong shoal and Dongbeixiaohong shoal are from the circumference

(Figure 4). The design capacity of the reservoir is 438 million m^3, and the area is about 66.26 km^2, which includes 11.3 km^2 vegetation covered wetland nearby water intakes and upper reaches of the reservoir. The middle reach and downstream of the reservoir is without vegetation covered wetland.

From the water quality monitoring data after the reservoir operation, the average value of NH_4^+-N, NO_3^--N, TN, TP in the outlet are 81%, 65%, 77% and 66% of the inlet respectively after flowing through the natural wetland in the reservoir (Figure 5). The water quality of the upper reaches of the reservoir is obviously improved, and the water quality in the middle and lower reaches is not obvious. Hydrodynamic would decline after the reservoir stopped taking water due to the salt tide occurred. When the salt tide occurred, the reservoir stopped taking water. The eutrophication level of the water body did not increase, but due to the growth of wetland purification time, further reducing the nutrient content of the water, thereby reducing the risk of water bloom.

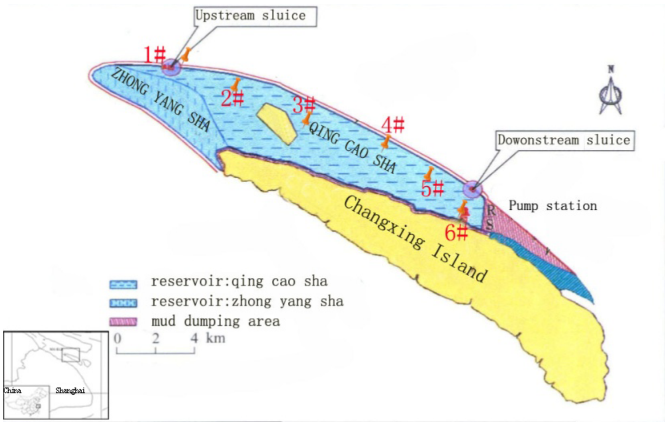

Figure 4. Monitoring points of water quality in QR.

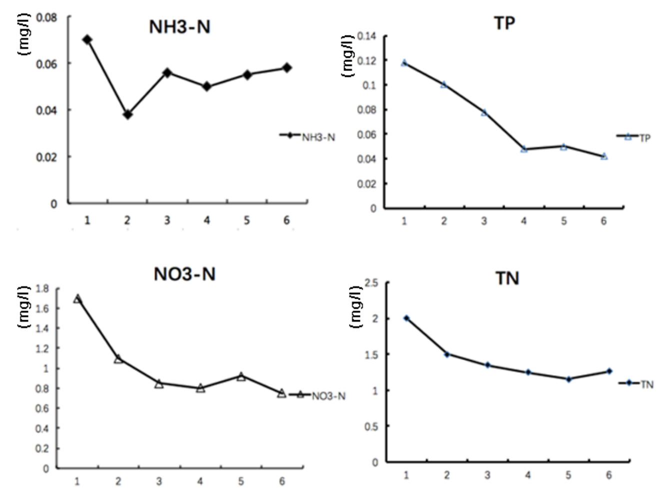

Figure 5. Average value of NH_4^+-N, NO_3^--N, TN, TP in six monitoring points in QR in 2011.

6 Conclusion

Along the coast, Phragmites australis, Scirpus mariqueter and Spartina alterniflora are the dominant plant species that stabilize the shoreline and provide habitat for wild animals. These natural communities, together with the sediments on tidal flats, contribute to the sequestration of nutrients from rivers and shallow water.

A series of wetlands upstream of the reservoir purify the raw water. The wetlands play an important role in taking clean water for the QR. At the same time, the wetlands in the reservoir area also play an important role in maintaining good water quality during salty tide.

In order to play the wetland for the reservoir water quality protection better, we propose to protect these upstream wetlands better, make the full use of existing wetlands, enhance the function of wetland water purification through ecological engineering methods, and construct artificial wetlands as a supplement.

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