Background of the Yuqiao Reservoir

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Geographic Setting

Tianjin as one of economic centers in the north of China is the third biggest city in China with an area of 11919 km^2 and a population of 10.5 million. The urban area is about 325 km^2, where about 5 million people lived. All the drinking water for the urban area is supplied through the Luanhe-Tianjin Water Diversion Project. As the key reservoir of Luanhe-Tianjin Water Diversion Project, the Yuqiao Reservoir is the main source of water supply for Tianjin (Figure 1a, b, c).

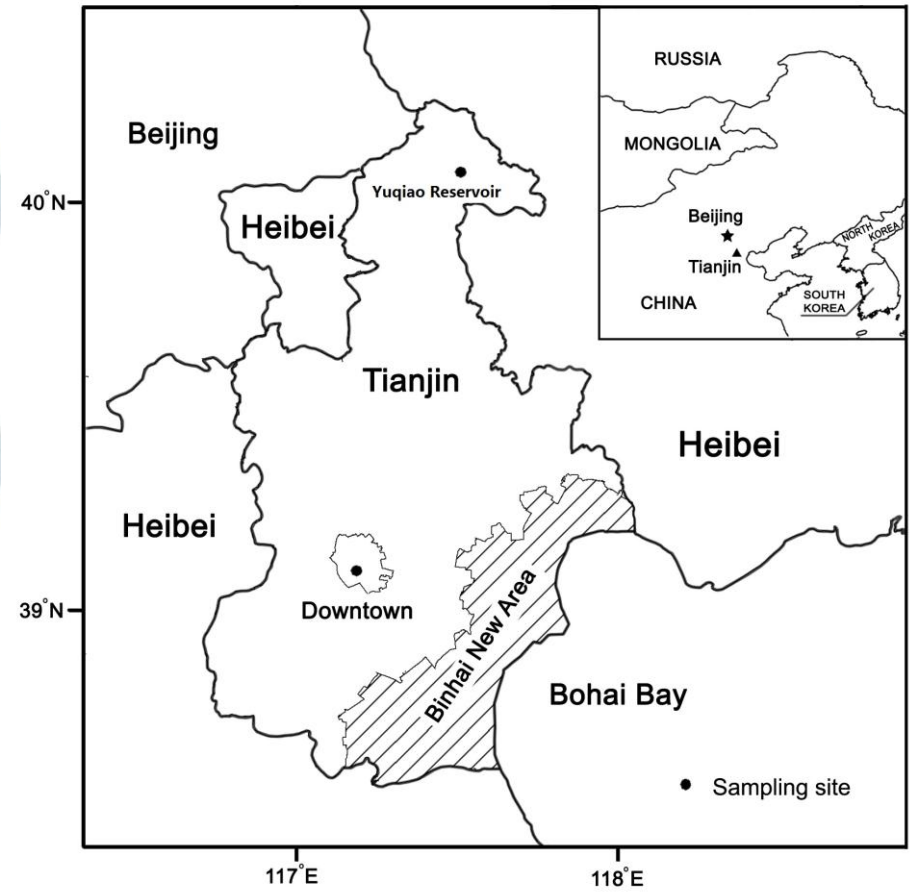

Figure 1(a) Location of the Yuqiao Reservoir

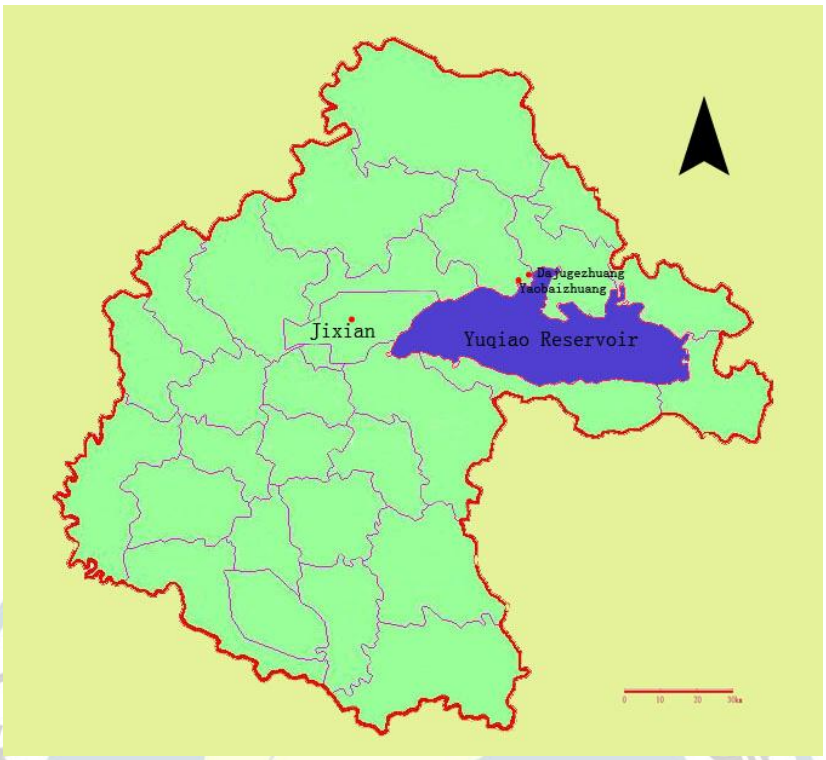

Figure 1(b) Yuqiao Reservoir in Jixian County, Tianjin

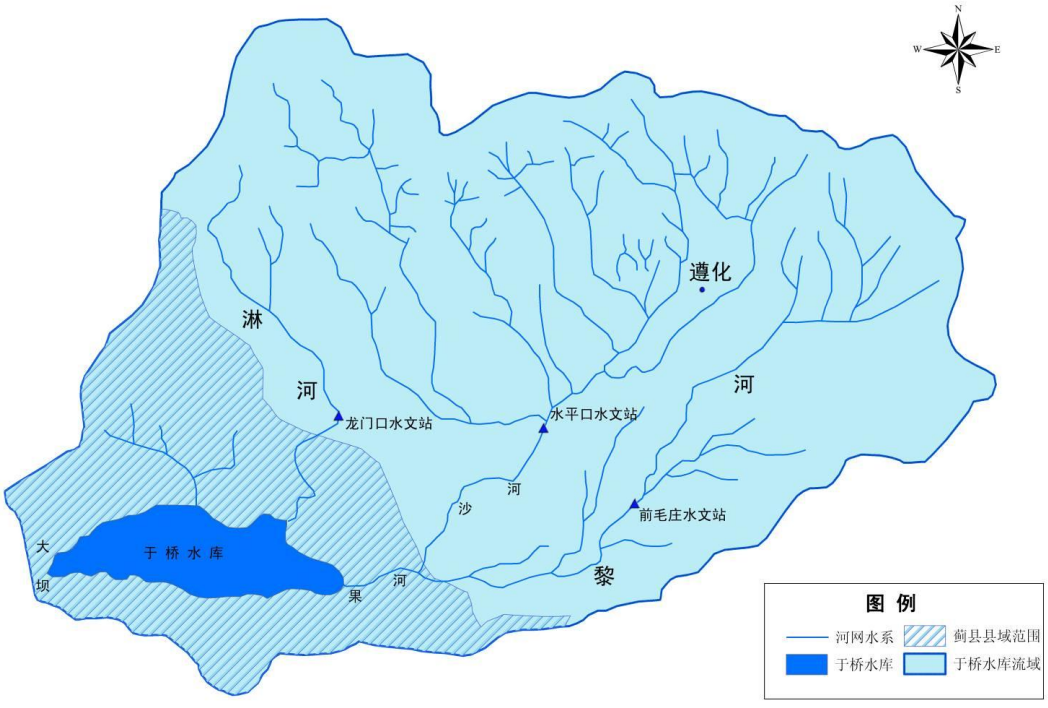

Figure 1(c) Watershed of the Yuqiao Reservoir

The Yuqiao Reservoir built in 1959 is located in Jixian County. The area of its

watershed is 2060 km^2. The capacity of water storage is 1.559 billion m^3。

As a part of Luanhe-Tianjin Water Diversion Project, the Yuqiao Reservoir is like a big water vat (source of water supply) for Tianjin citizens. The reservoir also has functions of irrigation, flood control and drought relief. More than 20 years after the Luanhe-Tianjin Water Diversion Project, the reservoir has supported the development and daily life for Tianjin. Up to date, more than 18 billion m^3 of drinking water were supplied to the urban area of Tianjin.

The significance of Yuqiao Reservoir to Tianjin is the same as that of Miyun Reservoir to Beijing. Both are important sources of water supply for metropolitan. Ecological environmental protection in the area is widely concerned.

Water problems

According to related study and monitoring for years, the water quality in the Reservoir shows a gradually worsening trend.

Eutrophication

Cultural eutrophication is a state of heightened biological productivity in a water body caused by the introduction of excessive amounts of nutrients and organic matter from human activities.

The water quality of the Yuqiao Reservoir has a pattern consistent with a water body suffering from eutrophication, as shown in Tables 1 and 2. The available data show that the Yuqiao Reservoir is moderately eutrophic and highly productive during the warmer months of summer and fall seasons as reflected by the high chlorophyll a levels and the reduced secchi depth, a measure of underwater visibility. The elevated concentrations of phosphorous and nitrogen, the high levels of chlorophyll-a, low transparency indicated by secchi depth and the trophic index are consistent with a

moderately eutrophied water body. Algal blooms are observed during this period of the year. The current data suggest that both TP and TN are limiting factors in the Yuqiao Reservoir, albeitat different times.

Table 1 Seasonal variation of water quality in the Yuqiao Reservoir.

Parameter (mg/l)	Spring	Summer	Fall
pH (S.U.)	8. 30	8. 61	8. 97
Dissolved Oxygen	8. 30	6. 67	8. 77
Secchi Depth (m)	4. 82	1. 32	1. 13
COD_{Mn}	2. 99	5. 44	4. 42
BOD	0. 693	1. 85	1. 39
Ammonia-N	0. 099	0. 351	0. 139
Nitrite-N	0. 016	0. 024	0. 052
Nitrate-N	1. 39	0. 421	0. 901
Total Nitrogen	1. 81	0. 840	1. 68
Total Phosphorous	0. 026	0. 074	0. 049
Chlorophyll a (mg/m^3)	3. 56	25. 1	21. 3

Table 2 Average seasonal water quality near the shoreline

Parameter	Dongmafang (mg/l)		Jibaihu(mg/l)	
	Dry Season	Wet Season	Dry Season	Wet Season
SS	3.8	4.8	4.8	4.2
COD_{Mn} (mg/l)	4.3	5.0	4.4	4.7
Ammonia-N (mg/l)	0.14	0.30	0.10	0.23
Nutrite-N (mg/l)	0.04	0.02	0.04	0.02
Nitrate-N (mg/l)	1.0	0.73	1.0	0.60
Total Nitrogen (mg/l)	1.5	1.0	1.6	1.0
Total Phosphorous (mg/l)	0.03	0.07	0.06	0.04
Chlorophyll-a (mg/m^3)	15.9	14.0	15.7	15.4

The high chlorophyll-a during the warmer months is consistent with heightened productivity fueled by high nutrient levels. The pattern associated with TP and COD (chemical oxygen demand using potassium permanganate) concentrations is generally consistent with the pattern of precipitation in the watershed. Concentrations of both TP and COD increase during the wet season when polluted runoff occurs and decrease during periods when the inflow to the reservoir is largely water diverted from the Luan He. This indicates the significance of surface runoff on water quality in the reservoir. The pattern of TN however, is the reverse, rising as TP and chlorophyll a declines and declining when TP and chlorophyll a rise. These patterns are an indication that TP is the limiting nutrient. Algal activity as measured by chlorophyll a follows the pattern of TP and is not influenced by the availability of TN. To be sure, the nutrient levels during summer and fall may also be influenced by releases from the sediment through benthic activity. The oxygen levels near the bottom show anaerobic conditions.

The fact that eutrophication level of water around the bank is higher than the water in central place of the reservoir proves again water is contaminated by surface runoff from village of north bank, farmland and raising farm. The terrain along the northern shore is flat and fishponds and farms mark the land. The flatness extends several kilometers from the northern shore, forming a shallow shelf about 1 to 2 meters deep. The terrain at the southern shore is steep with terraced farmlands and few fishponds, except for the eastern end where the terrain flattens. Research data suggest that the concentrations measured at Dongmafang near the northern shore are higher during the wet season for SS, COD, NH_3–N and TP, consistent with surface runoff and increased mixing effects due to summer storms. The correlation, however, is not as clear at Jiubaihu closer to the southern shore, where wet weather increases are observed for only COD and NH_3–N.

Sources of contamination

Early studies indicate that, for nutrients, the upstream sources accounted for 50% and 88% of the TP and TN influent loads to the reservoir, respectively. Surface runoff was estimated to contribute 13% and 2% of the TP and TN loads, respectively. The fish ponds contributed 32% of the TP and 5% of the TN loads into the reservoir. This new information has been used to refine the sources of nutrients and pathogens. These potential sources are discussed in detail.

Village: Runoff from villages is a significant source of pollution to the reservoir. The sources of pollution from the villages are non-point sources and include runoff from roadways, open piles of animal manure and other household wastes, and farmlands within and at the perimeter of villages. Toilets in the villages are outhouses. While the older outhouses are dry, the direction is to convert to flush toilets that use up to1 liter/flush. The wastes from the outhouses are periodically removed and directly applied as fertilizer. The wastes from flush toilets are contained in septic tanks, from which the effluent is periodically taken and applied on crop and orchard fields. Where animals are raised, manure is commonly collected in pits or piles along the roadside in front of the compound. Homes are typically heated with coal or farm residues such as corn stalks and wheat straw. During the winter, heating and cooking are usually co-uses that are carried out at the same fireplace.

Farm Land – Runoff, Inundation and Flooding: There are several areas around the reservoir with large crop fields located away from villages. Crops are typically corn, winter wheat and fruit trees. Since most of the agricultural fields have only a mild slope, are terraced, or are protected by elevated roads and berms, these farms appear to have low potential for significant runoff. Due to the limited availability of water for irrigation, there is very little excess irrigation water or irrigation return flows from these fields. During periods when the land is inundated with water diverted from the Luan He or flooded, it becomes a means of adversely affecting water quality with a source of nutrients and pathogens. The available data show groundwater contaminated with high levels of nitrogen, indicating that excess fertilizer is being applied. How

much of this excess fertilizer enters the water column and whether the time of the year that the land is inundated makes a difference needs to be assessed if water quality continues to deteriorate despite controlling other sources.

Hotel & Restaurants: The influx of vacationers poses a threat to water quality of the reservoir. Pollution loads produced by these facilities are substantial. If these wastes were discharged directly to the reservoir, they could have a significant impact on water quality.

Fish Ponds: Phosphorous load discharged from fish ponds is the largest single category of TP under the jurisdiction of Tianjin and Ji Xian. The significance of this source at the current time is uncertain. However, since these are controllable sources of nutrients they will have to be reduced to below levels that adversely affect water quality of the reservoir.

Internal Nutrient Loads: Internal nutrient loads are the nutrients that are released from sediments in the reservoir. Under proper conditions, the nutrients in the sediment are reintroduced or re-entrained into the water column adding to the nutrient budget for the reservoir. The physical characteristics of the Yuqiao Reservoir indicate that the optimal conditions for nutrient re-entrainment are not present. The model-predicted TP shows good correlation with the observed data for the Yuqiao Reservoir. Studies have shown that loadings from areas could contribute significant amounts of nutrients.