Comprehensive analysis of Water Pollution on Baiyangdian, China

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Abstract

Baiyangdian Lake is the largest freshwater lake and wetland in the northern of China. It plays an important role on maintaining ecosystem balance, adjusting climate of Hebei plain, supplying groundwater, and draining floodwater during the flood season. However, in recent decades, with the rapid population growth and influences of anthropogenic factors, water level has been decreasing year by year. The water area with water qualities of grade IV is 29.7% of the total area, and the area of grade V is 51.4%, and the area that is worse than grade V is 18.9%. The pollutant sources in Baiyangdian Lake are mainly organic contaminants, in which COD. TN and TP are much higher than the standards, and BOD_5 is more or less contaminated too. As the major inflow river into Baiyangdian Lake, Fu River carries large number of pollutants from Baoding City. By monitoring COD, TN and TP concentration of 8 sites in which S1and S2 are located in the Fu River, S3 to S7 are in the Baiyangdian. High pollutants concentration of Anzhou close to inlets of Fu River that indicates Fu River is the main pollution source of Baiyangdian Lake. Fu River flowing through Mancheng Country, Baoding City and Anxin Country absorbs large amounts of COD, TN and TP generated from domestic, industrial and agricultural wastewater of Baoding City. So controlling pollutants emission of Baoding City is effective for improving water quality of Fu River and reducing pollutants concentration of inlets of Baiyangdian Lake. But the current situation is low wastewater treatment capacity, recycling rate and unsound pollution emission fee regulation, and it is a long road to improve water quality of Baoding City. In addition, non-point source pollution from life of the residents, aquaculture and farmlands resulted from the villages will be studied in the future research.

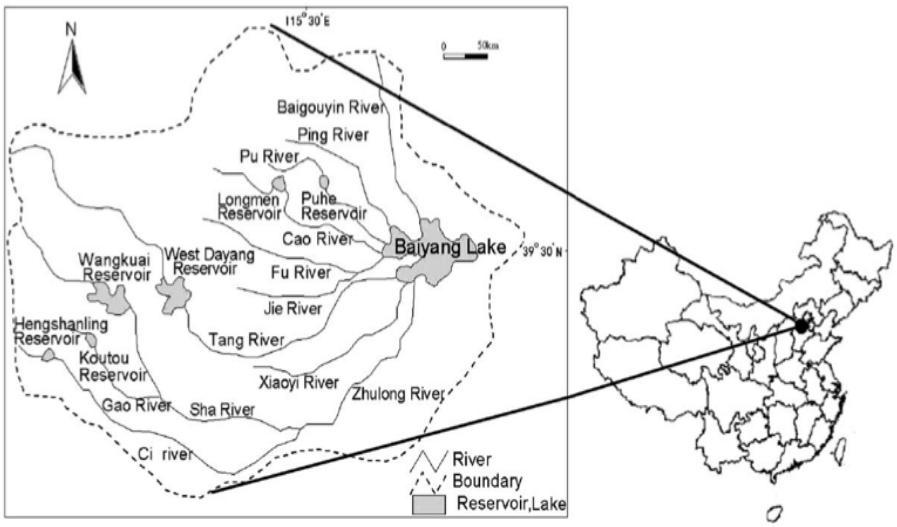
Key words: Baiyangdian Lake, water pollution, Baoding City, Fu River

1. Background

Baiyangdian Lake plays an important role on maintaining ecosystem balance, adjusting climate of Hebei plain, supplying groundwater, and draining floodwater during the flood season. However, in recent decades, with the rapid population growth and influences of anthropogenic factors, water level has been decreasing year by year. Now the water storage of Baiyangdian Lake is only 1/10 of that during 1960s, and the water quality of Baiyangdian Lake has been still becoming worse and worse, the water area with water qualities of grade IV is 29.7% of the total area, and the area of grade V is 51.4%, and the area that is worse than grade V is 18.9%. The pollutant sources in Baiyangdian Lake are mainly organic contaminants, in which COD. TN and TP are much higher than the standards, and BOD_5 is more or less contaminated too. As the major inflow river into Baiyangdian Lake, Fu River carries large number of pollutants from Baoding City. In addition, non-point source pollution from life of the residents, aquaculture and farmlands resulted from the villages within along Fu River caused excessive nutrient-rich pollutants directly discharging into the lake, which makes Baiyangdian Lake seriously eutrophied.

2. Study Area

Baiyangdian Lake（38° 43′ N to 39° 02′ N, 115° 45′ E to 116° 07′ E）is the largest shallow freshwater lake divided into about 143 lake parks in northern China. It is located in Hebei province. The total area of Baiyangdian Lake is 366 km^2 with 98 villages, and the average water depth is 8.4m. The population of Baiyangdian region is 168000. It is in the semi-arid zone characterized by continental monsoons. Its average precipitation is 556mm. The lake has served as a sink for the water of eight upstream rivers, including the Ping, Pu, Cao, Fu, Jie, Xiaoyi, Tang and Zhu River (Fig.1), with high aquatic biodiversity especially macrophytes, mainly reed, which were the dominate plant in the lake, possessed a large amount of species and quantities since 1950s.



Fu River is a major inflow river of Baiyangdian Lake with 63 km long, flowing through Baoding City. It originates from Mancheng Country with the end of Baiyangdian Lake. In recent year, both the Baiyangdian Lake and Fu River are strongly influenced by human activities.

Fig.1. The Baiyangdiang Basin and its geographical location in China

3. Objectives

- To gather knowledge of the scale and nature of the problem arising from different sources and industries
- Clarifying pollution sources of Baiyangdian Lake
- Estimation and distribution of the pollutants discharged from domestic and industry in Baoding city and Baiyangdian region in the future study

4. Methodology

In order to evaluate the water quality of Baiyangdian Lake, seven national monitoring and controlling sites (Fig2), Jiaozhuang (S1), Anzhou (S2), Anxinqiao (S3), Wangjiazhuai(S4), Guangdianzhangzhuang (S5), Juantou(S6), Caiputai (S7), were set to collect pollutants data in 2011. (Table 1)

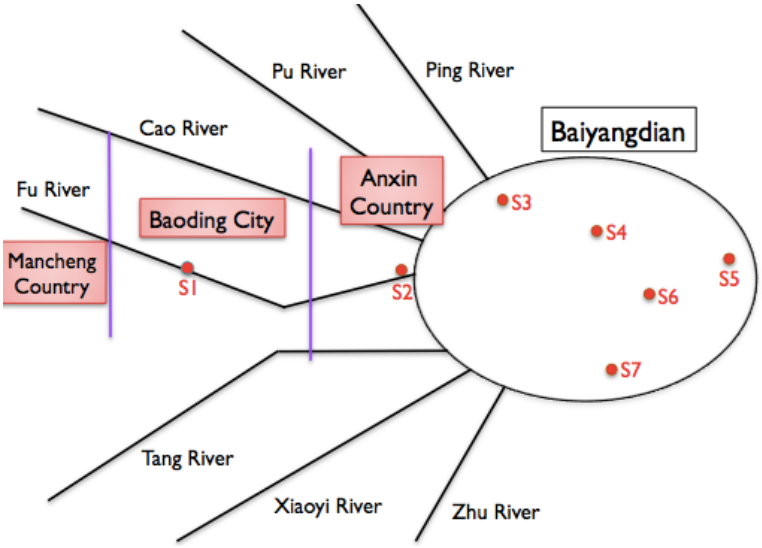


Fig.2. Distribution of monitoring and controlling sites

As the main inflow river into Baiyangdian Lake, the pollution situation of Fu River has great influence on pollutants concentration of Baiyangdian Lake. So two sites (Fig2), Jiaozhuang (S1), Anzhou (S2), located in the midstream and downstream of Fu River, were set to monitor pollutants concentration (Table 2) and calculate the single factor water quality identification indices of pollutants of Fu River from 2003 to 2008 (Table 3).

Single factor water quality identification index

Single factor water quality identification index (P) selects the representative pollutants factors and combines the function classification of water body to calculate indices of different pollutants which showing the situation of water quality.

$P_i = X_1 . X_2 X_3$

When $I \leq i < V$:

$$X_1 . X_2 = \alpha + \frac{\rho_i - \rho_{min}}{\rho_{max} - \rho_{min}}$$

$$X_1 . X_2 (DO) = (\alpha + 1) + \frac{\rho_i - \rho_{min}}{\rho_{max} - \rho_{min}} \times m \quad (m = 4)$$

When $i \geq V$:

$$X_1 . X_2 = 6 + \frac{\rho_i - \rho_{ClassVmax}}{\rho_{ClassVmax}}$$

X1. X_2 (DO) = 6 + $\frac{\rho_{ClassVmax}-\rho_i}{\rho_{ClassVmax}}$

X_i: Class i of water quality
ρ_i: Measured concentration
ρ_{max}: Maximum number of Class i of water quality
ρ_{min}: Minimum number of Class i of water quality
α : 1, 2, 3, 4, 5 (classification of water quality)
m: Revising coefficient
$\rho_{ClassVmax}$: Maximum number of Class V of water quality

$X_3=X_1- f_1 (1 \leq X_3 \leq 9)$
X_3: Second digit after the decimal point
f_1: Water Function Class
When $X_3 > 9$, $X_3= 9$

Next step, besides the date of pollutants, TP, TN and COD, I will also collect a series of socio-economic indicators such as GDP, population, investments, production and flows of goods and services into the market system. Regarding the available date, all industrial sectors are reclassified into 7 categories by using input-output table. Then the water pollution parameters are used for each sector related to emission factors per unit of production.

5. Discussions

Table1 Component concentration of 7 sites of Baiyangdian Lake in 2011

Sites	Component (mg/l)		
	COD	TP	TN
S1 (Jiaozhuang)	38.6	3.1	47
S2 (Anzhou)	37.4	2.1	33
S3 (Anxinqiao)	15.0	0.7	10.6
S4 (Wangjiazhai)	13.0	0.5	3.9
S5 (Guangdianzhangzhuang)	6.9	0.04	0.7
S6 (Juantou)	6.3	0.06	0.8
S7 (Caiputai)	6.0	0.05	1.0

Table1 shows COD, TP, TN concentration of 7 monitoring sites showing polluted situation of water quality, is also listed on the left. The results indicated that in 7 sites the main pollution were COD and TN, followed by TP and NH4+-N, and DO was well except P1. The pollutants concentration of S2 located in inlets of Fu River is much higher than other sites except S1. And there were no signification differences among S4, S5, S6 and S7. The water quality of S5 was better than other sites, which shows that the water quality of outlets was better than the inlets, because of the self-purification of water body.

According to Environmental Quality Standards for Surface Water, which is listed below (State Environmental Protection Administration of China, 2002), Class I, II and III of water can be used for domestic drinking. From Table 2, NH4+-N, TN and TP concentration of S2 that were much higher than 7.0 indicates that inlets of water has been seriously polluted, especially major inflow river, Fu River. For S1 site, there are no accurate indices of pollutants to show the water quality classification. In order to clearly indicate the pollutants situation of S1, I will continue to collect date and calculate the indices of different pollutants.

Table2 Single factor water quality identification index of 8 sites of Baiyangdian Lake in 2009(Journal of Agriculture University of Hebei, 2011)

Sites	Indices					
	DO	COD_{Mn}	COD_{Cr}	NH_4^+-N	TP	TN
S2	2.9	5.31	5.61	13.29	10.76	15.89
S3	1.0	4.71	4.81	3.1	3.0	4.91
S4	1.2	4.91	4.81	3.3	4.41	4.81
S5	1.9	4.71	4.51	3.0	3.3	4.41
S6	1.6	4.61	4.41	3.1	3.6	4.91
S7	1.6	4.61	4.41	2.9	3.1	4.71

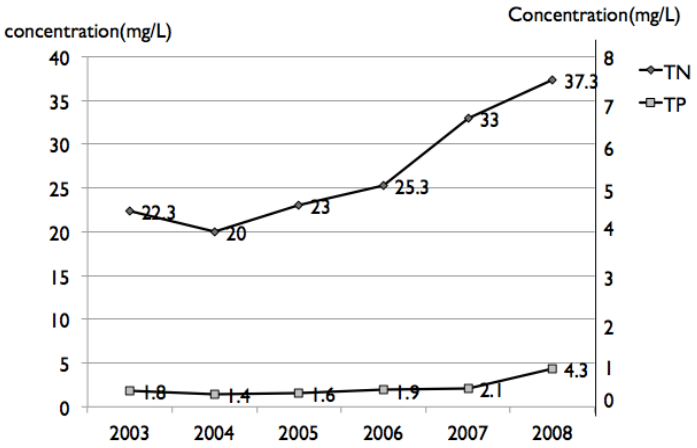
Index standard

1.0≤P≤2.0 Water Quality Class I
2.0＜P≤3.0 Water Quality Class II
3.0＜P≤4.0 Water Quality Class III
4.0＜P≤5.0 Water Quality Class IV
6.0＜P≤7.0 Water Quality Class V
6.0＜P≤7.0 Water Quality Class Inferior V (polluted water without black color and odor)
P＞7.0 Water Quality Class Inferior V (polluted water with black color and odor)

Environmental Quality Standards for Surface Water (classification standard: water functions)

Class I: source water, National Nature Reserve
Class II: centralized drinking water source, rare aquatic habitats, fish and shrimp production field etc.
Class III: centralized drinking water, swimming areas, migration channels, aquaculture area etc.
Class IV: industrial water, recreational water
Class V: agricultural water, general landscape waters

Table3 Average concentration of TN and TP of Fu River from 2003 to 2008



From 2003 to 2008, both TN and TP concentration of Fu River have increasing trends totally (Table 3), and it shows the changes of TN and TP of Fu River in the 6 years. Pollutants concentration of S1 close to Baoding City is higher than other sites (Table1), which shows that a large amount of wastewater is discharged from Baoding City.

High concentration of TN and TP tested in Anzhou (S2) shows that a large amount of polluted materials have been inflowing into Baiyangdian Lake though Fu River in recent years. Monthly averages of precipitation and temperature of Fu River changed very little from 2003 to 2008 based on Baoding City Environmental Protection Bureau. So in this study, water pollution of Fu River caused by atmospheric factor is ignored. From Table4, although the regional of Baiyangdian discharges wastewater into lake, the total amount of COD, TN and TP is far less than the one from outer edge of Baiyangdian. External sources are still the main pollution source of Baiyangdian Lake. Fu River flows through Mancheng Country, Baoding City and Anxin Country. Especially domestic, industrial and agricultural wastewater generated from Baoding City contains large amounts of COD, TN and TP, and these pollutants are almost discharged into Fu River and Baiyangdian Lake.

Table4 The types of pollution source in Baiyangdian Lake

Index	Sources						
	External sources(%)			Interior sources(%)			
	Domestic pollution source of the outer edge	Industrial source of the outer edge	Domestic pollution source of the edge region	Industrial source of the edge region	Domestic and tourism source of the regional	Aquaculture of the regional	Sediment release
COD	58.3	16.2	4.8	4.4	7.2	9.2	0
TN	51	20.4	4	3.5	5.5	2	13.6
TP	43.9	10.5	3.1	3.1	4.2	14.2	20.9

Therefore, Controlling pollutants emission of Baoding City is an effective method to improve water quality of Fu River and reducing pollutants concentration of inlet of Baiyangdian Lake. Firstly, treatment capacity of sewage treatment factories directly relates to the water quality of Fu River and Baiyangdian Lake. But now sewage treatment situation of factories is serious. There are 3 main sewage treatment factories, Lugang, Yindingzhuang and Xiyuan, with 200,000 t/d wastewater treatment capacity in Baoding City, while total amount of wastewater (domestic, industry and agriculture) of Baoding City is 260,000 t/d. Secondly, low recycling rate of wastewater influences emission control of Baoding City. In 2010, sewage treatment factories treated 76.4 million m^3 wastewater, but total amount of recycling is just 30.6 million m^3 with 18.36 million m^3 of Baoding district. The recycling rate is less than 50%, and much more water cannot be second-used. In order to improve water quality of Baoding City, some measures are adopted. One is building more sewage treatment factories and introducing new technology to expand treatment capacity. The other one is increasing wastewater emission fee to 0.85 RMB/m^3 for residents, 1.00 RMB/m^3 for enterprises and institutions.

Otherwise, there is another important source, non-point pollution loads in villages along the Fu River. The daily discharge of sewage and household wastes from the villages is a large amount in which the household wastes contribute greatly to the N and P pollution loads of the Fu River, with the relevant entering loads as high as about 70%, and COD is about 13.1 t/y. In the future study, pollutants emission control in the villages along the Fu River will be studied.

By using Single factor water quality identification index method, indices of different pollutants were calculated. The result shows that main pollutants of Baiyangdian Lake are NH4+-N, COD, and TN. Water quality of Anzhou close to inlets of Fu River is most serious in 7 monitoring sites that indicates Baoding city and Baiyangdian region is the main pollution source of Baiyangdian Lake. Through analysis on the types of pollution source in Baiyangdian Lake, external sources, especially domestic pollution source mainly from Baoding City account a large proportion in total amount. As a result, controlling pollutants emission of Baoding will be a future task in reducing pollutants contents of Baiyangdian Lake. For interior sources, there are 168000 people, who are living in the 98 villages, and 20000 visitors per day of Baiyangdian region, so large amounts of domestic and tourism waster water are emitted into Baiyangdian directly. And with the development of local economy and tourism, wastewater generation will be increasing in the future.

TN and TP concentration of Fu River was increasing from 2003 to 2008. The concentration is much high than the standard of water quality, and water body is Class Inferior V. The highest concentration is Jiaozhuang monitoring site that shows main pollutants of Fu River come from domestic, industrial and agricultural wastewater of Baoding City, so controlling pollutants emission of Baoding City can greatly decrease the COD, TN and TP pollution of Baiyangdian Lake. But the current situation is low wastewater treatment capacity, recycling rate and unsound pollution emission fee regulation, so it is a long road to improve water quality for Baoding City.

Besides, household wastewater generated from villages along the Fu River should not be ignored in researching Fu River pollution. In the future study, it is another important research objective for improving the water quality of Fu River and Baiyangdian Lake.

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