Journal of Lake Sciences, Vol. 10, Suppl., pp67-74, 1998.

Total Quantity Control Planning & Harnessing Measures for Water Pollution of the Inflow Rivers to Taihu Lake*

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Abstract: *The water pollution situation of Taihu Lake, general conditions of the main inflow rivers to Taihu Lake, the compiling principles, the harnessing measures for polluted water and major inflow rivers to the lake, and the total quantity control plan were analyzed.*
Keywords: *Total quantity control for water pollution, Taihu Lake*

Taihu Lake, as the third largest fresh water lake in China and covering an area of 2 338 km^2 with several functions such as water supply, irrigation, tourism, navigation, flood control, is the main water supply source within Taihu Basin. At present, Taihu Lake is severely polluted and eutrophication is increasingly worsened, which influences people's daily life and restricts economic development. It is high time to harness pollution of Taihu Lake. To harness the pollution, it is necessary to determine prevention objectives of water pollution, upon which a control planning for total quantity of pollutes is to be prepared and harnessing measures implemented to practice. Study shows that the major pollutes are flowing into the lake through rivers. Therefore, preparing a control planning of total quantity for pollutes of river and practical harnessing measures are the key to effectively control water pollution and stimulate continuous development of basin economy.

1. Water pollution situation

1.1 Water quality of Taihu Lake

At present, the water of Taihu Lake is severely polluted. 76% of total water area as average a whole year is poorer than Class IV surface water. The main pollutants are TP, TN and COD_{Mn}; water body is eutrophic and algae reproduced in great amount, i.e. 30 000 000 cells·l^{-1} and biomass as much as 5 mg·l^{-1}. Since in the mid 1980's, the eutrophication has been rapidly

* Received 1997-02-25; accepted 1998-03-27.

developed, it is indicated that concentration of TP, TN has increased and expansion of eutrophication area has been sped up and algae broken up, grown and duration lasted longer; the amount of algae and biomass has dramatically increased.

1.2 Water quality of inflow rivers to Taihu Lake

The water quality of more than half inflow rivers poorer than Class V. Main pollutants are TP, TN and COD_{Mn}. In recent years, the water quality is obviously worsened, polluted rivers' length has increased, concentration grown, and water quality of majority of rivers decreased by 1- 3 classes.

1.3 Analysis of pollution source

Pollution source includes wastes drained by human and various activities related to production, it may be classified according to professions, i.e. industry and domestic pollution sources, livestock and poultry pollution source, aquaculture pollution source. In recent years, the total quantity of pollutants loading into water body of Taihu Lake and its basin from upstream is as follows: COD_{Cr} 377 000 $t \cdot a^{-1}$, TP 5 000 $t \cdot a^{-1}$, TN 45 000 $t \cdot a^{-1}$. The contribution rate by all those pollution sources to COD_{Cr} is: industry > human > livestock and poultry > aquaculture > precipitation and dust in river and lake; to TP, human > livestock and poultry > aquaculture > agriculture > precipitation and dust in river and lakes; to TN, human > agriculture > livestock and poultry > aquaculture > precipitation and dust.

2. General conditions of main inflow rivers to Taihu Lake

2.1 Taihu Lake is a water collecting and relieving area for river network within Taihu Basin. There are now 219 rivers as inflow and' outflow. The inflow rivers are mainly located in Huxi of Jiangsu Province and Zhexi of Zhejiang Province, including Zhehugang water system, Caoge water system, Nanxi water system, Jinxi water system and Huangxi water system, Liangxi River serves as outflow water system in 40% of a whole year, the river flows into Taihu Lake which cause certain pollution to Meilianghu section of Taihu Lake, so it is expected to be harnessed as an inflow river.

2.2 Pollution source of Taihu Lake, about 70 % of pollutes are from river. Zhihugang water system conveys polluted water of Canal stretch of Changzhou - Wujing - Qishuyan to Taihu Lake; Taoge water system conveys part of polluted water of Danyang and Jintan to Taihu Lake, Nanxi water system conveys polluted water of Liyang and Yixin to Taihu Lake. Hexi water system conveys polluted water of Sian and Changxin of Zhejiang Province to it; Tiaoxi water system collects and conveys polluted water from Anji, Lian, Deqing and Huzhou to the lake.

3. Total quantity control planning for major inflow rivers to Taihu Lake

3.1 Compiling principle

3.1.1 The plan is expected to reflect a principle of comprehensive harnessing and to take Taihu Lake and its inflow rivers as a whole. Combining planning objectives of the lake and rivers and control of pollute quantity, for the purpose of ensuring the water quality of Taihu Lake and inflow river to reach planning objectives by decreasing of pollutes quantity.

3.1.2 Combination of short-term and long-term, comprehensive planning and implementing by stages.

3.1.3 Combination of total quantity control and concentration control, i. e. total quantity control as objectives and concentration not exceeding the indexes of Class III surface water.

3.2 Compiling procedures

3.2.1 Investigation, monitoring, analysis and calculation of basic materials.

3.2.2 Preparing planning objectives of Taihu Lake water pollution prevention.

3.2.3 Calculation and analysis of pollution load quantity, max. allowable load quantity and min. expected decreasing quantity of Taihu Lake existing situation.

3.2.4 Calculation and analysis of pollution load quantity max. allowable load quantity, min. expected decreasing quantity of inflow rivers existing situation.

3.2.5 Preparation of harnessing alternatives and measures according to the total quantity control planning of pollutes.

3.3 Planning and objectives of water pollution prevention

3.3.1Objectives for the year 2000 as short-term

The first period (1996-1998): the discharge of pollution source as industry and intensive aquaculture within the whole basin will reach certain criterion.

The second period (1999-2000), water quality (containing TP, TN) in control section of Taihu Lake will be Class II and in bank section Class III, effectively control the development trend of Taihu Lake eutrophication and as a result, the beautiful appearance of Taihu Lake with clear water will recover. The water quality of inflow rivers is controlled on the basis of Taihu Lake max. allowable load and min. expected decreasing quantity and corresponding quantity is distributed to gain the water quality of planning objectives, The water quality above Class III will be corrected by indexes of Class III water.

3.3.2 Objective for the year 2010 as long-term

The whole lake water reaches Class II and a positive circulation of the ecological system of Taihu Lake is resumed. The inflow rivers will ensure to realize water pollution prevention objectives for Taihu Lake water body.

3.4 Total quantity control planning for Taihu Lake pollutants

3.4.1 Existing pollution load of Taihu Lake

The outer pollution source of Taihu Lake is in-outflow rivers (reversible flow), bank area surrounding the lake and pollutants are directly accepted by lake surface. Recently, the existing pollution load of Taihu Lake is COD_{Cr} 56 300 $t \cdot a^{-1}$, TP 1 700 $t \cdot a^{-1}$, TN 37 500 $t \cdot a^{-1}$. The contribution rate is in-outflow rivers > lake surrounding area > lake surface area. The inflow quantity by inflow rivers accounts for about 70% of the total quantity into the lake. Obviously, it is the first step to harness and control inflow river pollution for Taihu Lake water pollution prevention and harnessing.

3.4.2 Maximum allowable load of Taihu Lake

The maximum allowable load means: under design water quantity of dry season and water quality of planning objectives for water pollution prevention, the max. pollution load allowed into the lake. According to calculation, the planning water quality for the year 2000: max. allowable load of Taihu Lake COD_{Mn} 44 900 $t \cdot a^{-1}$, TP 1 100 $t \cdot a^{-1}$, TN 8 100 $t \cdot a^{-1}$; the planning water quality for the year 2010: COD_{Mn} 37 700 $t \cdot a^{-1}$,TP 720 $t \cdot a^{-1}$, TN 6 000 $t \cdot a^{-1}$.

3.4.3 Min. expected decreasing quantity of Taihu Lake pollution load

The existing pollution load exceeds max. allowable load, so the should be decreased to reach planned water quality objectives, As the year 2000's objectives: Taihu Lake shall decrease at least COD_{Mn} 11 400 $t \cdot a^{-1}$, TP 6 300 $t \cdot a^{-1}$, TN 29 400 $t \cdot a^{-1}$; the year 2010, COD_{Mn} 18 600 $t \cdot a^{-1}$, TP 980 $t \cdot a^{-1}$ and TN 31 500 $t \cdot a^{-1}$.

3.5 Total quantity control planning of major inflow rivers to Taihu Lake (the year 2000 objectives)

Tab. 1 Maximun allowable load and minimum expected decreasing quantity of the major inflow rivers to Taihu Lake

a. $COD_{Mn}(t.a^{-1})$

Province	Water System	Pollution load of CON_{Mn}			
		Existing	Order	Allowable	Decreasing
Jiangsu	Liangxihe	2 272	6	963	1 309
	Zhihugang	4 407	4	1 869	2 538
	Taoge	7 508	3	6 084	1 424
	Nanxi	10 735	1	8 700	2 035
	Subtotal	24 922		17 616	7 306
Zhejiang	Hexi	4 217	5	3 417	800
	Tiaoxi	9 491	2	9 023	468
	Subtotal	13 708		12 440	1 268
Total		38 630		30 056	8 574

b. TP ($t \cdot a^{-1}$)

Province	Water System	Pollution loads of TP			
		Existing	Order	Allowable	Decreasing
Jiangsu	Liangxihe	20	6	12	8
	Zhihugang	98	5	60	38
	Taoge	259	2	159	100
	Nanxi	171	3	105	66
	Subtotal	548		336	212
Zhejiang	Hexi	153	4	94	59
	Tiaoxi	385	1	237	148
	Subtotal	538		331	207
Total		1 086		667	419

c. TN ($t \cdot a^{-1}$)

Province	Water System	Pollution loads of TN			
		Existing	Order	Allowable	Decreasing
Jiangsu	Liangxihe	1 941	6	195	1 746
	Zhihugang	3 645	4	366	3 279
	Taoge	4 208	3	825	3 383
	Nanxi	8 096	2	1 584	6 512
	Subtotal	17 890		2 970	14 920
Zhejiang	Hexi	3 021	5	591	2 430
	Tiaoxi	8 373	1	1 641	6 732
	Subtotal	11 394		2 232	9 162
Total		29 284		5 202	24 082

3.5.1 The existing pollution load of major inflow rivers to Taihu Lake: max. allowable load, min. expected decreasing quantity are shown in Tab. 1.

3.5.2 Data shown in Tab. 1 show: COD_{Mn} contribution rate: Nanxi > Tiaoxi > Taoge , Zhihugang > Hexi > Liangxi River; TP, Tiaoxi > Taoge > Nanxi > Hexi > Zhihugang > Liangxi River; TN: Tiaoxi > Nanxi >Taoge > Zhihugang > Hexi > Liangxi River.

3.5.3 Meilianghu section and Wulihu section in the northern part of Taihu Lake, except for pollutants from the section's surrounding area, mainly accept pollutants conveyed by Zhihuga.ng water system and Liangxi River. The sections account for 5.8 % of the total area of Taihu Lake but accept pollutants from those two water systems, that accounts for 11 % 19 % of total pollutants from major inflow water systems, which indicates that Meilianghu section and Wulihu section have become the most polluted sections of Taihu Lake and that is closely related to pollution of Zhihugang and Liangxi River.

4. Harnessing measures for polluted water and major inflow rivers to Taihu Lake

4.1 General principle for measures determination

4.1.1 Water pollution prevention for major inflow rivers to Taihu Lake is a comprehensive systematic project, including engineering and non-engineering measures.

4.1.2 Priority control procedures of pollution source

COD_{Cr}: industry > human > livestock and poultry

TP: human > livestock and poultry > aquaculture > agriculture

TN: human > livestock and poultry > agriculture >aquaculture

4.1.3 Key points of sectional harnessing: as Mailianghu section and Wulihu section are most severely polluted, and the sections of Jiangsu Province with great contribution rate of pollution load and directly threatened by water pollution, therefore, Jiangsu Province should put more effort to water pollution prevention.

4.1.4 Harnessing measures of pollution source should be prepared for main key problems of the section, and implemented under a plan and by stages.

4.1.5 Water conservancy projects will play an important assistant role in harnessing water environment . It is expected to make full use of ten key components and water conservancy facilities constructed within Taihu Basin and to increase the environmental capacity of Taihu Lake and river network by optimized distribution and subsequently to improve water quality.

4.1.6 Non-engineering measures mainly as strengthening administrative management to prevent water pollution, intensifying the system of combining section management and whole basin management, speeding up establishment of legal systems and strengthening the implementation of laws and regulations.

4.2 Harnessing measures for major inflow rivers to Taihu Lake

4.2.1 General harnessing measures

* 78 main industrial pollution sources' discharge conforming to standards

* Establishing a domestic sewage treatment plant with a total capacity of 320 000 $t \cdot a^{-1}$, by technology of dephosphorization and deoxitation

* Popularizing and using non-P detergent

* Controlling chemical fertilizer quantity consumption and decreasing loss of N and P

* Collectively treatment to sewage discharged by large-sized livestock and poultry farms

* Propose to construct sluice in Zhihugang and Wujigang to make full play to its functions as flood control and restrict sewage; make full use of existing water conservancy components and optimize distribution to improve water environment.

4.2.2 Harnessing measures for Zhihugang water system

11 key industrial pollution sources, within Zhihugang water system (including Zhihugang and Wujin), discharge sewage under certain standard. It is proposed to construct Zhihugang and Wujin

sluices to harness the canal stretch of Changzhou - Wuxi.

4.2.3 Harnessing measures for Liangxi River

9 key industrial pollution sources along banks of Liangxi River discharge sewage under certain standard; complete harnessing of 11 industrial pollution sources along Wuxi stretch of canal, expanding sewage treatment plant and completing corresponding facilities; making full play to Dushankou water conservancy project to improve water environment.

4.2.4 Harnessing measures for Taoge water system

23 key industrial pollution sources within the scope of Caoqiao River and Yingfenggang discharge sewage under a certain standard; a sewage treatment plant with a capacity of 50 000 $t \cdot a^{-1}$ to be established in Jintan City; nitrogen fertilizer consumption for 1 733 km^2 of paddy field to be decreased; non-P detergent to be popularized for 2 200 000 people instead of previous detergent with P to decrease P loss; sewage and manure from 50 % of large-sized collective livestock and poultry farms to be collected and treated.

4.2.5 Harnessing measures for Nanxi water system

11 key industrial pollution sources within the scope of Nanxi water system (including Yilie River, Zhandugang) discharge under a certain standard; a sewage treatment plants with a capacity of 50 000 $t \cdot d^{-1}$ to be established in Liyang and Yixin respectively; to decrease pollutes collected from livestock and poultry farms by 46% by constructed sewage treatment facilities to change wastes into treasures; to decrease chemical fertilizer consumption of 927 km^2 of paddy fields; to popularize using non-P detergent for 1 600 000 people

4.2.6 Harnessing measures for Hexi water system

12 key industrial pollution sources within Hexi water system discharge under a certain standard; a city sewage treatment plant with a capacity of 60 000 $t \cdot day^{-1}$ to be established in Changxing county; chemical fertilizer consumption to be decreased for 200 km^2 of farmland; non-P detergent to be used by 380 000 people; sewage from livestock and poultry farms to be treated by 30%.

***4.2.7* Harnessing measures for Tiaoxi water system**

12 key industrial pollution sources within Tiaoxi water system (including West Tiaoxi and East Tiaoxi) discharge under a certain standard; sewage treatment plants with a total capacity of 160 000 $t \cdot d^{-1}$ in Wuzhou, Anji and Deqing; non-P detergent to be used by 1 980 000 people; chemical consumption to be decreased for 767 km^2 of farmland; sewage from large-sized livestock and poultry farms to be treated by 30 % as treatment rate; water and soil conservation work to be done for Tiaoxi upstream.

4.3 Non-engineering harnessing measures

4.3.1 To strength leadership system for water pollution prevention by combining section management and basin management; to strictly carry out total pollution quantity control and prepare and implement harnessing measures, to intensify monitoring and management of the water quality of control cross-sections of inflow rivers to ensure it conforming to the requirements of planning objectives and subsequently guaranteeing the realization, of planning objectives for

Taihu Lake water pollution prevention.

4.3.2 To stipulate laws and regulations for basin water pollution prevention. First to urgently stipulate water pollution prevention regulations for Taihu Lake and inflow rivers to strengthen the implementation of harnessing pollution by laws.

4.3.3 To establish and perfect supervision system of Taihu Basin water environment. Previously monitoring of water environment for inflow rivers is relatively weak, it is expected to strengthen . Taihu Basin Water Resources Protection Bureau has stipulated and been carrying out monitoring scheme for inflow river control cross-sections. It is proposed that Jiangsu and Zhejiang provinces stipulate and carry out corresponding water quality monitoring program for the scope of river control cross-sections, which is beneficial for unified monitoring and management of water environment.

4.3.4 To strengthen scientific study and to popularize new technology and professions.

5. Conclusion

The state pays closed attention to water pollution prevention for Taihu Lake (including inflow rivers). Harnessing Taihu Lake has been listed as a key point in the Ninth Five-Year Plan. It is expected that the water of Taihu Lake will become clear by the year 2000 and that is also an urgent requirement of people living in Taihu Basin. The leading group of water pollution prevention for Taihu Basin has been established and now organizing to prepare planning. The presentation of the paper may be provided for state's compiling plan. It is believed that under the unified leadership of the leading group, the provinces and the municipality may jointly harness water pollution, with the support of relevant departments of the state council and efforts of people living in the basin, the planning objectives for water pollution prevention can be realized.