Chapter 1
Water Pollution and Its Control in the Tai Lake Basin

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1. Brief Introduction of the Tai Lake Basin

Tai Lake ("Taihu" in Chinese) is situated between 30°5'–32 °8'N and 119° 8'–121°55'E, in the eastern part of China (see Figure 1). It is the third largest freshwater lake in China, with a catchment area of 36 500 km^2, a water surface area of 2338.1 km^2, and an average water depth of 1.9 m. The annual average air temperature is 14.9 8°C–16.2 8°C.The annual mean precipitation is 1000–1400 mm, and the annual mean runoff into the lake is 4100 million m^3.

Located in the junction of Shanghai, Jiangsu and Zhejiang Province, Tai Lake Basin is one of the most developed areas of China, playing a significant role in the development of national economy. Till 2003, it covers 0.4% of the national area, and has 3% of the national population and creates 11% of the GDP of China. The local financial revenue accounts for 13.8% of national revenue[1].

Fig. 1. Location of Tai Lake

Source: Wang, Zhang et al. (2004).

[1] Jiangsu Statistics Yearbook, 2004

2. Water Pollution and Crisis in the Tai Lake Basin

Since the 1980s, the lake has experienced dramatic water quality degradation associated with rapid land development and the developing economy. The water quality is poor and 3 northern bays suffer from annual algal blooms, which increase cost of water purification.

In the early eighties, the water quality of Tai Lake is about Class II. Till 2003(Fig. 2), in the eastern Tai Lake and the east coast of Tai Lake, water quality is III, all the year around, which comprises 16.5% of the evaluation area. In Meiliang Lake, Wuli Lake and Zhushan Lake, water quality is worse than V, which comprises 8.2% of the evaluation area; in other areas of Tai Lake, water quality generally is IV, which comprises 75.3% of the evaluation area.

Besides, Tai Lake provides drinking water for about 30 million people in the provinces of Jiangsu, Zhejiang and Shanghai Municipality. However, Tai Lake has been heavily polluted since the 1980s, and about 800 sq km is covered with the fast-growing and foul-smelling green plant. The situation deteriorated in May last year when the lake suffered from a massive blue-green algae outbreak that threatened the water supply to more than 1 million residents of Wuxi. This event has aroused extensive concern both at home and abroad. Although every year, a large amount of Yangtze River water was channeled into the lake to dilute the pollution, the water pollution indicators remained high.

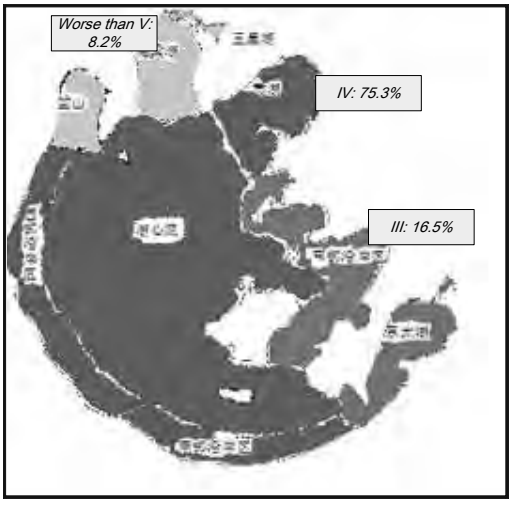

Fig. 2. The Water Quality of Tai Lake in 2003

Source: Water quality survey report in 2003, unpublished

3. Reasons for Pollution in the Tai Lake Basin

Many factors contribute to the pollution in the Tai Lake Basin.

(I) Industrial development is the most important aspect. During 1980s to middle 1990s, China township enterprises sprung up and developed rapidly, such as chemical industry, metal smelting, printing and dyeing industry and so on. These industries had backward technology and low-efficiency environmental management, which caused heavy pollution in the Tai Lake Basin. At that time, pollution control by the government was almost blank. From middle 1990s, high energy consumption and high water consumption industries still occupied large part of the local industry. Though the government had noticed the importance of pollution control and enacted such local regulations as Water Pollution Prevention Statute of Tai Lake in Jiangsu Province, the pollution continued becoming worse.

(II) Population in urban areas increased rapidly, resulting in large amounts of municipal waste discharge. Since the Tai Lake Area is one of the most developed areas in China, it is with a high urbanization level. In 2000, population density of this area is 928 person/km2, compared with 130 person/km2 of China. Population density of Shanghai Central Area, Suzhou Urban district, Wuxi urban district, Changzhou district and Yixing and Changxing City is 21,705, 2,824, 2,183, 3,152, and 500 person/Km^2, respectively. Non-rural area population grows rapidly. Taking 1990-2006 as an example (Table 1), the Non-rural area population increased nearly 50% in the following cities.

(III) Agriculture pollution is another main source. Although with the development of industry, farmland reduces rapidly in some areas, agricultural foundation of the Tai Lake Area is still strong, being the intensive cultivation. Cities and counties with per capita arable land area more than 0.05hm2 are Jiaxing, Changzhou, and Huzhou, Dantu, Danyang, etc.

Table 1. Population Growth in Seven Main Cities

Year	Wuxi	Changzhou	Suzhou	Shanghai	Jiaxing	Huzhou
1990	144.31	81.41	139.75	864.46	58.39	43.66
1991	148.05	82.8	142.19	869.88	58.92	43.95
1992	151.45	97.57	149.17	875.55	61.17	45.02
1993	167.18	115.11	155.33	893.46	62.49	46.66
1994	169.96	116.02	161.98	910.49	63.96	48.88
1995	180.77	120.48	168.55	921.7	66.81	50.03
1996	183.88	124.71	176.00	932.14	68.2	51.82
1997	173.63	128.47	186.18	943.03	70.34	54.2
1998	171.04	131.1	192.88	953.65	73.21	58.98
1999	176.45	138.75	206.45	969.63	76.18	60.56
2000	183.45	147.81	246.34	986.16	78.59	65.56
2001	182.77	151.43	265.76	999.07	83.55	70.96
2002	191.07	157.82	274.28	1018.81	85.1	72.21
2003	272.77	159.68	290.07	1041.39	101.31	74.47
2004	279.39	159.86	297.62	1097.6	108.42	76.37
2005	315.61	160.56	309.71	1148.94	112.20	77.81
2006	331.04	161.20	321.42	1173.30	115.99	78.41

Source: Statistic Yearbook of Jiangsu, Zhejiang and Shanghai, 1991-2007.

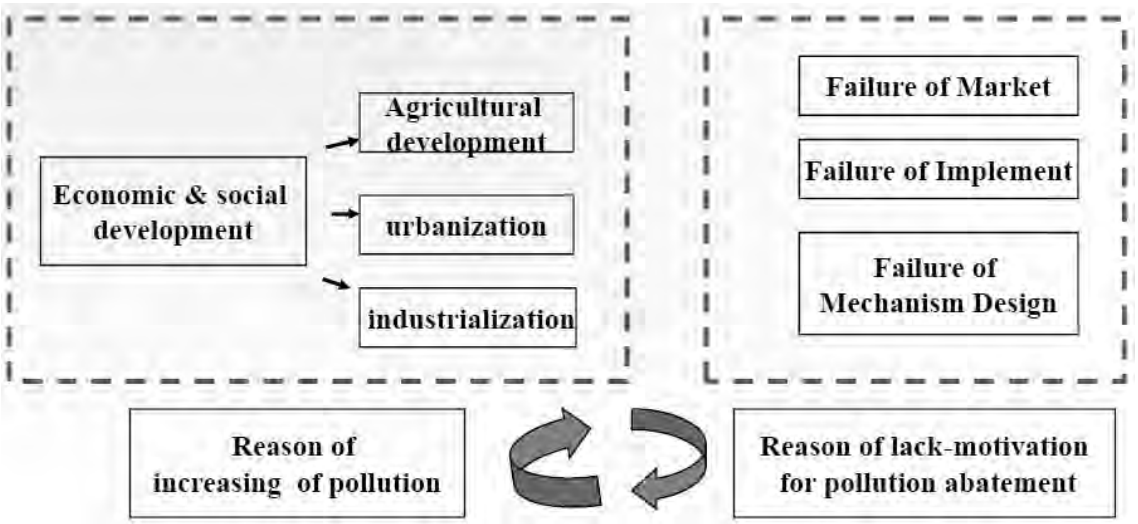

Fig. 3. Development and Institution Failure: the causes for pollution

Till now, industrial pollutants, domestic wastewater and agriculture pollution have been considered as the major contributors. Also the institutional failure made the situation worse (Figure 3).

Thus, the governments are determined to take non-compromised measures to prevent and control pollution.

4. Control Action in the Tai Lake Basin

According to the reasons of water pollution, the government mainly makes efforts in three aspects (Figure 4). Integrated water management projects and multi-policy instruments are practiced in the Tai Lake Basin.

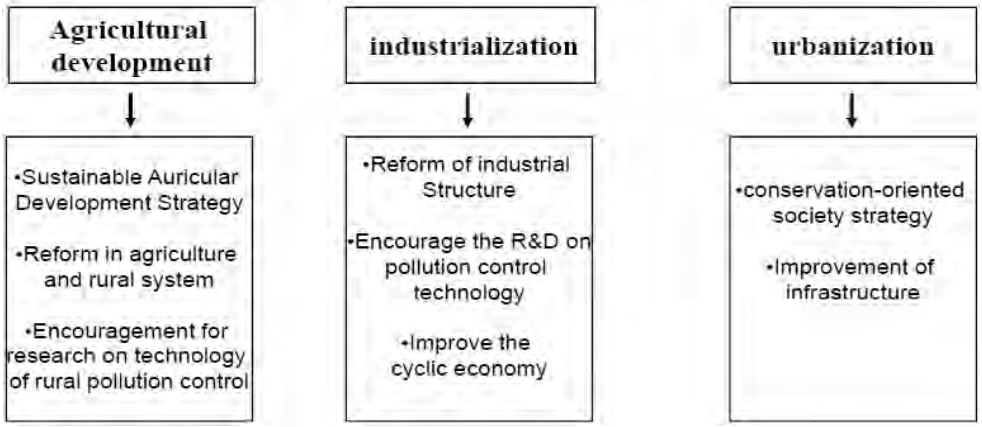

Fig. 4. Efforts of the Government

The integrated water management project

The integrated water management project in the Tai Lake watershed was launched by the Jiangsu provincial government in Dec. 2007, shortly after the Blue-algae Accident.

In this project, the provincial government sets two sets of objectives including the pollutants discharge objectives and the water quality objectives, till 2012(Table 2). The former set of objectives includes the COD, ammoniate, total phosphor and the total nitrogen indicators. Among which, the latter two ones are the new indicators. In the past, the government mostly focused on the COD indicator. Now, they also concern the phosphor and nitrogen indicators, Since total phosphor and the total nitrogen are the key indicators to cause blue algae outbreak.

If the objectives are achieved, the situation of water environment in Tai lake will be much better. Also the long term objectives were set. Each level of government should be responsible for these objectives.

To achieve these objectives, a series of measures and programs are supposed to taken (Figure 5).

Table 2. Short-term Objectives of the Project in 2007-2012

Pollution Discharge Objectives (10 thousand tons)				
Year	COD	NH3-N	TP	TN
2005	85.03	9.18	1.04	14.16
2012	71.98	7.03	0.82	10.84
Water Quality Objectives (mg/l)				
Year	Mn	NH3-N	TP	TN
2005	4.9	0.47	0.08	2.95
(Classification)	Ⅲ	Ⅱ	Ⅳ	Worse than Ⅴ
2012	4.5	0.46	0.07	2.0
(Classification)	Ⅲ	Ⅱ	Ⅳ	Ⅴ

Source: Cited from the integrated water management project in Tai Lake 2007.

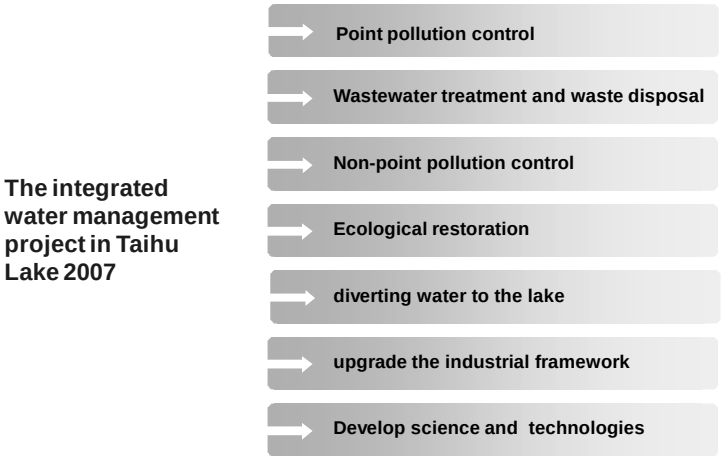

Fig. 5. Main Contents of the Project

In this project, the stricter discharge standards, including COD, NH3-N, TN, TP and water use, are implemented in such industries as Wastewater treatment plants, Chemical, Papermaking, Steel, Electroplating and Food manufacturing. Also stricter access standards are regulated in the Tai Lake Basin. Besides, the enterprises with out-of-date technologies will be closed.

Industrial structures are to be optimized. Traditional industry such as chemical, printing and dyeing, steel should be adjusted. While, the high-tech industry such as IT and new material industries will be supported and developed. And, the tertiary industry will be greatly improved.

Price reform is promoted. From 2007, the pollution equivalent of waste gas raised from 0.6 to 1.2 yuan/kg. The pollution equivalent of waste water increased from 0.7 to 0.9 yuan/kg (and will raise to1.4 yuan/kg in the near future). The wastewater treatment fees changed from 1.3 to1.6 yuan/ton. And, the rate of domestic sewage treatment in 2010 will achieve 60%. From 2008, t the exceeding discharge of NH3, TP will be charged in wastewater treatment plants.

In addition, Environmental Protection Investment (EPI) will be increased to 3% of regional GDP in 2010. Growth rate of EPI are required to be no less than that of GDP. And, private capital is encouraged to invest in environmental infrastructure Construction.

5. Policy Instruments in the Tai Lake Basin

5-1 Four types of policy instruments

Multi-types of instruments were used to control pollution in the Tai Lake Basin. The traditional command and control instruments (CI) include:

- Pollution discharge limit, based on allowable pollutant concentration
- Mass-based controls on total provincial discharge (pilot application in selected municipalities)
- Environmental impact assessment
- Three synchronization policy
- Limited time treatment
- Centralized pollution control
- Two compliance policy
- Environmental compensation fee
- Phase-out of leaded gasoline
- Risk Management

The economic incentive instruments (EI) include:

- Pollution levy fees
- Non-compliance fines
- Discharge permit system (experimental)
- Sewage tariff regulation
- Sulfur emission fee (experimental)
- Subsidies for energy-saving products
- Regulation on Green Credit

The Voluntary instruments (VI) include:

- Environmental labeling system
- ISO 14000 system
- Cleaner Production program
- Environmental model cities
- Environmental responsibility system (mixed VI and CI)

And, the public disclosure instruments (PI) include:

- Clean-up campaigns
- Environmental awareness campaigns
- Comprehensive evaluation system for city environmental quality
- Air pollution index disclosure
- Environmental information disclosure of industrial enterprises (experimental)

In addition, new Instruments of water management regulation include:

- Tradable Permit Experiment In the Tai Lake Basin
- Pilot Environmental Compensation System, and
- Regional Environmental Cooperation Platform for Yangtze River Delta

The following section will introduce the Tradable Permit Experiment in the Tai Lake Basin.

5-2 Pilot COD emission trading program in the Tai Lake Basin in Jiangsu Province

In order to control the total emission of the main pollutants, as well as improve the monitoring capacities, in 2008, the new piloted program titled the COD emission trading program was designed by the Jiangsu Provincial EPB. Establishing a trading platform (Figure 6) for the firms who discharge COD pollutants, it began with the total emission control and the trading among 133 industrial firms and 75 wastewater treatment plants (WTPs), which have been equipped with continuous monitoring systems and directly discharge wastewater into Tai Lake.

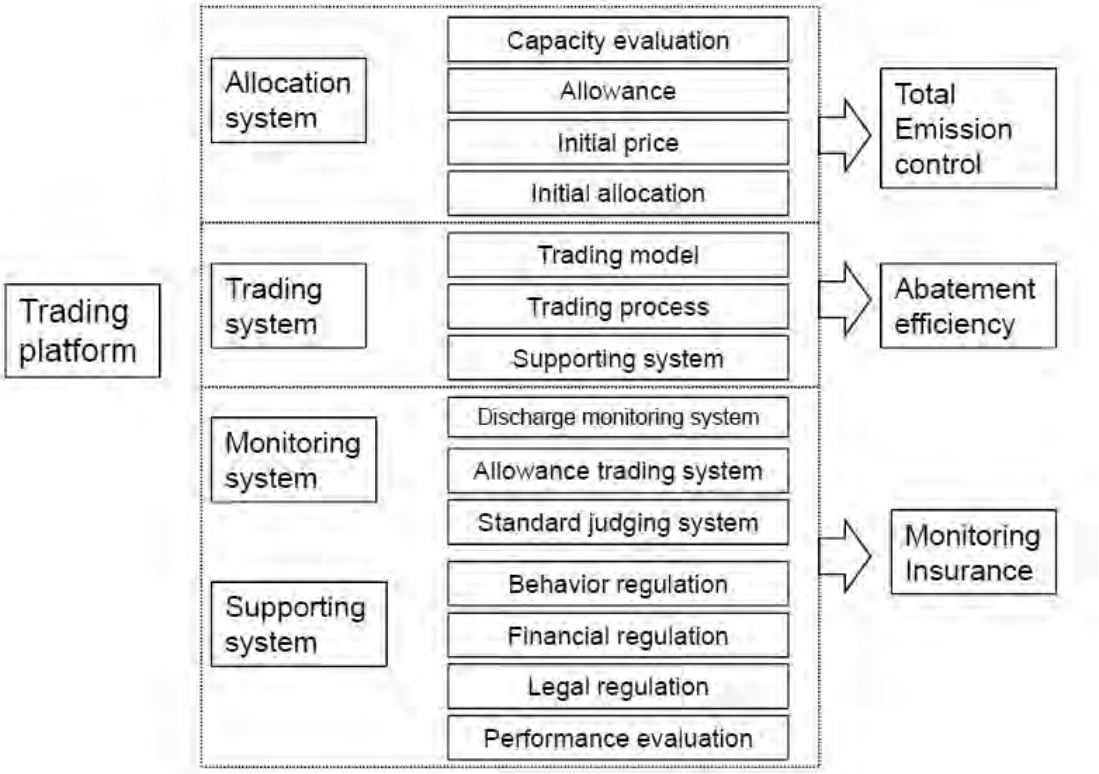

Fig. 6. Trading Platform for the COD Emission Trading Program

Based on the Environmental Registration System (ERS) of 2007, the regulator determines the total amount of the "permit" of these targeted firms. Then the regulator allocates the permit with the fixed initial prices. Each firm is obliged to hold an amount of permits basically based on its historical self-reporting in ERS. Finally, each year if a firm's emissions exceed its permit, it has to buy the excess amount from other firms. Alternatively, if a firm's emissions are lower than permitted, it can sell the excess allowance to other targeted firms or new firms that do not have permits. Firms can also sell excess allowances back to the government, which promises to buy them at the initial price. Now the initial price was temporarily set at 4600 yuan/year/ton.

In order to improve enforcement, as well as increase the monitoring capacity, three sub-systems are established. The discharge monitoring system is supposed to track the pollutants emission. In this system, the 133 targeted firms and 75 targeted WTPs are equipped with the continuous monitoring instrument, which is supposed to provide continuous and accurate measure of emissions and send it to the monitoring center. The allowance tracking system is supposed to track the initial permits each firm holds and the permit they buy or sell on the market. It also tells whether the on-line monitoring measure matches the allowance tracking database. The third system, standard-meeting

judgment system, is to tell whether the emission meets the local environmental standards. If not, the trading behavior of this firm is forbidden. And, these three systems will be operated and maintained by the professional third party, who is provided subsidies by the government. It helps to raise the reliability of these systems.

To increase the detected possibility of violation, another checking system (titled cross-checking system) is set up, in which many indicators are collected such as production, electricity use, raw material consumption, water, the technological process and so forth. The correlations among the various data collected are checked by some small and sophisticated programs and the COD emission is simulated by Gabi 4, which is a Life Cycle Assessment simulation program. If the records of the monitoring system are far from the simulation results, they will be doubted and canvassed by the regulators. It's a strategy to deal with the "hidden pipes". Also the disclosure among each other or by the public is encouraged.

6. Further possible efforts

Improvement of governance structure

Now the vague responsibility is still one of the characteristics of the Water Management of Tai Lake. Since multi-sectors are responsible for the water quality and water volumes (Figure 7), each sector only concerns their own responsibility. Thus the water management objectives could not be achieved.

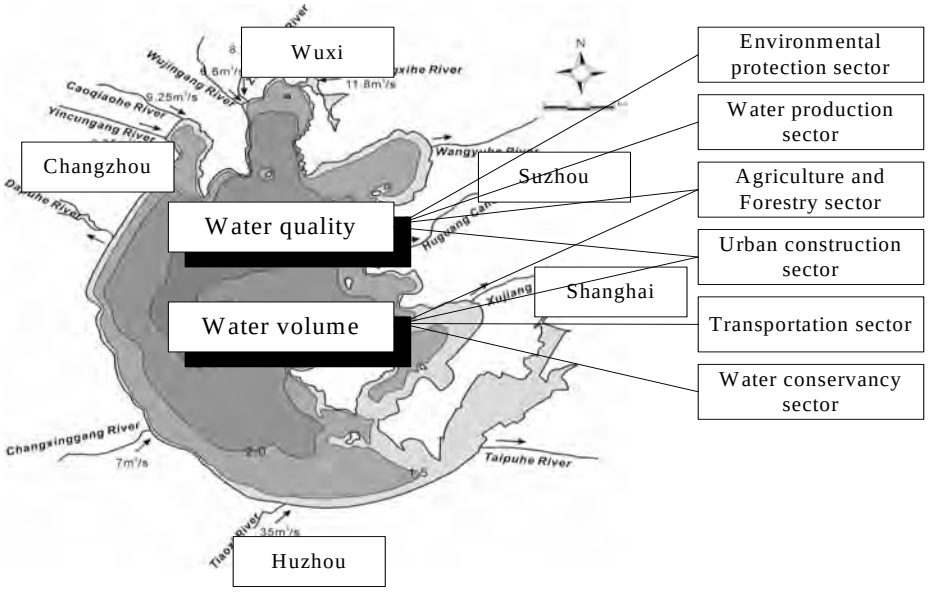

Fig.7. Responsibility of Each Sector

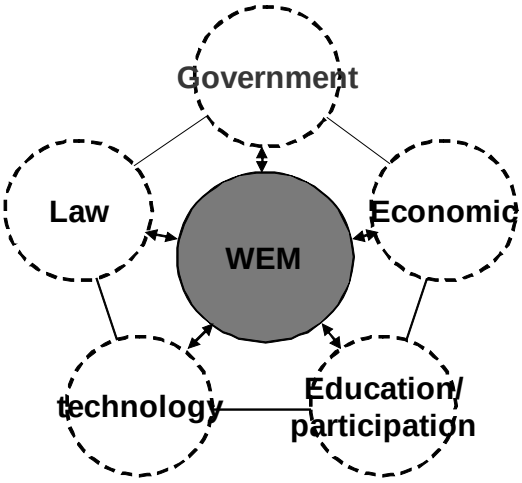

Fig. 8. Ideal Governance Framework

Since, the government should promote the water management institution reform to integrate the sectors within the government and multi-stakeholders to improve the water management (Figure 8).

First, the government should establish a regional institution special for Tai Lake water resource management and pollution control (it is done but not effective) , and, well define power and responsibility for each related agencies, such as local EPB, water resource department, Construction department and so on.

Some efforts have been done. By the end of 2005, 3 cities, including Suzhou, Suqian and Huai'an and 34 counties such as Jiangdu, Baoying have established Water Bureau to integrate the water management in their administrative regions. Also the reform of Target System of Government was moved on. Environmental protection has been regarded as an important proxy for government judgment. In addition, Public participation and information disclosure are provincial-widely on promotion.

Risk prevention of the Tai Lake Basin

The Blue-Algae Accident alarmed that the risk management in Tai Lake is still weak (Box 1). In order to strengthen the risk management system, the government should:

- Establishing regional environmental risk and emergency system
- Improving risk identification
- Improving risk evaluation
- Improving risk forecast model, and
- Improving emergency response

Box 1 The blue-green algae accident in Wuxi City

On May 22th 2007, a blue-green algae bloom broke out. It suddenly caused degradation of water quality in portable water sources of Wuxi on May 30th. On May 31st, Water shortage (Drinking water) crisis of Wuxi took place. On June 2nd, the technical team succeeded in dispelling the unpleasant odor from the water supply of east China's Wuxi city, but the water is still not safe to drink. On June 4th Wuxi government announced that the water from Wuxi's faucets is safe.

More issues need to resolve and possible solutions

Other issues related to water management in the Tai Lake Basin are the following:

- Lack of information of pollution sources and analytical ability
- Unclear of carrying capacity and zoning is not well done
- Lack of monitoring
- Lack of warning system and emergency plan, and
- Lack of integrated instruments
- Focus on a specific area other than the watershed
- Focus on engineering solution other than management tools
- Focus more on end-of-pipe solution other than whole-process management (from cradle to tomb, from cradle to cradle)
- Focus on individual techniques other than integrated and optimized techniques
- Lack of watershed management solution

And, the government, as well as related stakeholder should look for possible solutions, including:

- Promoting whole process management
- Promoting watershed management
- Launching TMDL system
- Exploring integrated solutions

All these solutions should be economically and long-term feasible, dynamic and adaptive.

Reference

Wang, X., W. Zhang, et al. (2004) "Modeling and simulation of point-non-point source effluent trading in Taihu Lake area: perspective of non-point sources control in China." *Science of the Total Environment*, 325, 39–50.