Past and future effects of socio-economic development on the aquatic environment of Lake Taihu

Junfeng Gao

（Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, Nanjing 210008, China）

* Corresponding Author:
Junfeng Gao
Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences
East Beijing Road 73, Nanjing 210008, P. R. China
E-mail: gaojunf@niglas.ac.cn

Abstract:

Taihu lake basin is one of the most developed districts in China. In the past 20 years the economy developed very fast. The annual growth rate of GDP reached 11.6%, the rate of urbanization increased by 31% and the gross output value of industry increased 13 times. However, the area for crops and irrigated land decreased constantly. Industrialization, urbanization and agriculture affected the quality of water environment profoundly. In the 90s of 20th century, the length of the river with the quality exceeding the standard raised 23%, and the quality of Taihu lake declined by two grades. In the future, the economic growth rate will stay at about 10%, and the water requirement will increase also the water environment will further deteriorate in near future.

Keywords: Taihu Basin, socio-economic development, water environment, effects

Introduction

Taihu lake basin (119°08′～121°55′E，30°05′～32°08′N) covers an area of 36895 km^2. It is located in the south of Changjiang River, the west of China East Sea, the north of Qiantang River and the north of Tianmu mountain (Mao hill). The basis is divided in two main parts: a center with large plains and mountains up to 1500m at the borders. The flat part contains many water bodies. The west mountainous area in the basin is upper reaches of the basin, and the east is a river system of network of water system in downstream plain. The areas of the upper reaches and lower reaches account for 45.2% and 54.8% of the whole basin respectively.

The annual average general precipitation of Taihu lake basin is 1176 mm and the total

amount of annual average water resource is $17.7*10^9$ m^3.

In 2000, the result of Taihu lake basin comprehensive water quality appraisement (According to the standard of groundwater environment GB3838-2002) indicated: 2.9% of of the river are of water quality of class Ⅱ. Class Ⅲ, Ⅳ, Ⅴ and Ⅴ plus account for 12.7%, 21.1%, 9.8%, and 53.3% respectively. Water quality of 84% of the river worse than the standard value. The Chinese index of water quality standard includes dissolve oxygen, potassium permanganate, chemical oxygen demand and ammonia nitrogen.

The distribution of water quality in Taihu Lake is 92.0%, 2.4%, 5.3%, 0.3% of lake surface in class Ⅲ Ⅳ Ⅴ and Ⅴ plus. The major pollution originates from ammonia nitrogen, COD_{Mn} and petroleum, etc. The state of Taihu lake is heavy eutrophic except east Taihu lake which is mesotropic.

Socio-economic development

The GDP of Taihu lake basin is $971.7*10^9$ ¥ in 2000, $108.1*10^9$ ¥ in 1980, having increased nearly 8-fold, average annual increase is up to 11.6%. From 1980 to 1990, the average annual increase is 9.1%. In 1990s, economy developed extremely fast with an average annual increase of up to 14.2%, 5.1% more than last ten years. The economic contribution (GDP) of the upper reaches district with 10.6% is much lower than the 89.4% of the downstream district. .

During the past 20 years, the economy in Taihu Lake Basin grew very fast and attracted a large number of people from other places. From 1980 to 2000, the total population in the basin grew from $3.169*10^7$ to $3.953*10^7$, which makes a total increase of $7.18*10^6$ and an average annual rate of 1.03%. The upper reaches district increased by $1.35*10^6$, the downstream district by $5.48*10^6$ persons. The average annual increase in the upper reaches is slightly higher than the downstream district. The population density in the east of the basin is higher than in the west. The the development of economy also caused a higher degree of the urbanization. The basin urbanization rate rose from 35% in 1980 to 66.5% in 2000. The values of the downstream district were again higher than the average of the basin, increasing by 33.2% over the past 20 years to 71.6% in 2000 (Fig. 1).

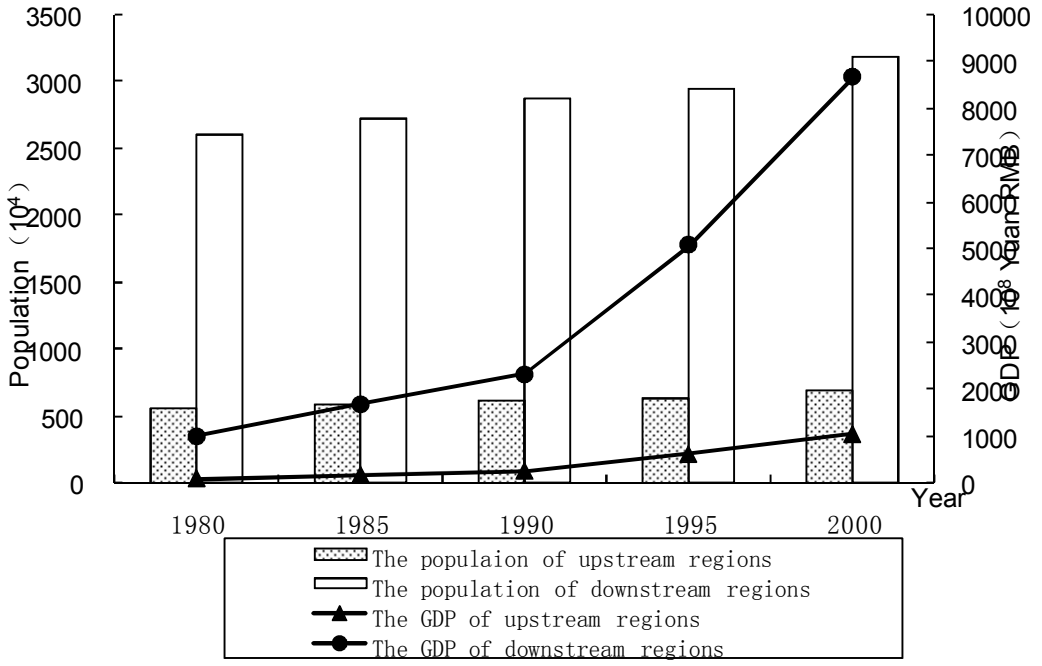

Fig 1 The changes of the population and GDP in Taihu lake basin in the past 20 years

In 1980, the total industrial production of the Taihu basin is $133.5*10^9$ Yuan (RMB), the total added industrial production is $48.3*10^9$ Yuan (RMB). In 20 years afterwards, total industrial production and added industrial production are $1.86*10^6$ Yuan (RMB) and $471*10^9$ Yuan (RMB) in 2000, with the average annual increase 14.1% and 12.1% respectively. From 1990 to 1995, the industry production increased very fast comparing to other periods. The average annual total industrial production increase was up to 22.7%, and added industrial increase was up to 20.0%. The industry distribution centers were in the downstream district which account for 89.1% of the total basin output. The upper reaches region accounts only 10.9%.

The industry in Taihu basin is in a process of advanced status with characters of heavy industrialization and high mechanization. Industrialization started with light and textile industries. After reform, opening-up and the development of open-economy, greater changes have taken place in the industrial structure. In the late 1980s, the manufacturing industry developed progressively, especially factories for electric and electronic devices developed very fast. In 1990s, the heavy chemical industry was established. Actually, the most important industries in the region are: some machinery, electronics, petrochemistry, car maufacturers, telecommunication equipment, transport and communication, electric, chemical raw materials. The proportion of textile industry declined by some small extent.

Taihu lake basin used to be “heaven of fish and rice”, because of the grain-production and efficient irrigation. During the past 20 years, land use by agriculture has decreased continually (see table 1). The mains reasons are the low income from cereals and agricultural structural adjustment. From 1980 to 2000, cultivated area decreased from $356*10^4$ to $249hm^2$, but the area used for cash crops increased. The irrigated farmland has been reduced by $10.7*10^4$ hm^2 to $132.6*10^4$ hm^2. The ratio of the cereals to cash crops of the upper reaches district is higher than that of downstream district, and that of western mountain area is higher than eastern plain district.

Since the eighties of last century, the quantity of the big livestock of Taihu lake basin (ox, horse) has been decreasing, but the small livestock , such as the chicken, duck, etc. is growing. In 2000, the big livestock, pigs and sheep, chickens and ducks were $1.1*10^6$, $1.3*10^7$, and $6.441*10^7$. Compared with 1980, the quantity of big livestock and pig and sheep decreased by 32.5% and 25.9%, and the number of chicken and ducks increase by 73. 1%..

Impact of socio-economic development on water resources

From 1980 to 2000, with the fast development of economy, the total water consumption of Taihu Lake Basin increased from $23.4*10^9$ m^3 in 1980 to $3.16*10^9$ m^3 in 2000 (35%) with an annual growth rate of 1.5 % (Fig 2).

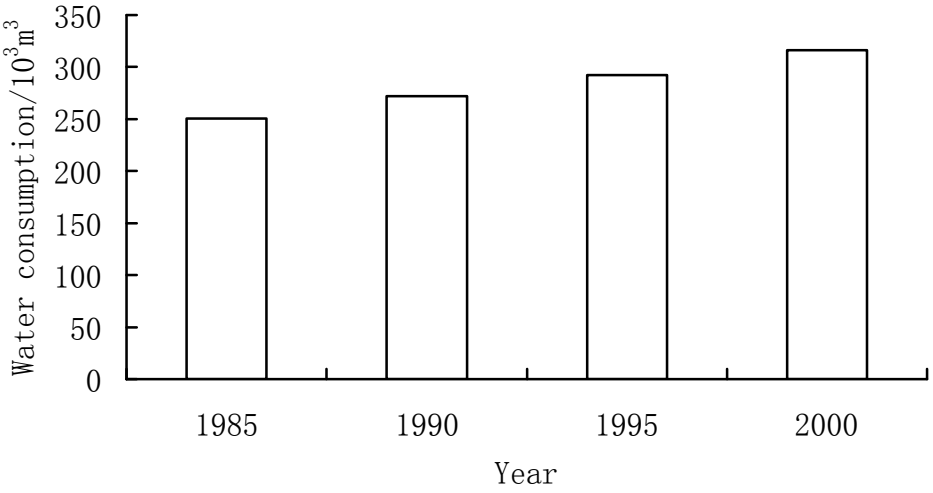

Fig. 2 Water consumption in the past 20 years in the basin

The water is mainly used for private consumption, industry and agriculture. In the past 20 years, for the fast growth of the population and the improvement of the living condition in the basin, water consumption increased by 5.5%/a. Because of the improved technology, the increase of water consumption in general industry is relatively low, even began to decrease. Because of increasing consumption of electricity, the water use by thermal and nuclear power plants is increasing constantly, causing a higher water consumption by industry with an annual increase up to 3.4%. The proportion of industrial water consumption to total water consumption of the basin rose by 16.2% in 20 years. The adjustment of the agricultural structure and the improvement of the irrigation technique reduce agricultural water consumption. Due to the loss of agricultural land for urbanization and construction, the agricultural water consumption is greatly reduced, thus buffering the growth rate of the water consumption in the whole basin.

From 1980s, water quality in Taihu lake basin aggravated obviously (Table 1). With the exception of the flood years 1991 and 1993 , the river is polluted on more than 55.0% of the run length with a maximum of 80.0% in 1996. In ten years, the part with the water quality of class Ⅱ reduced gradually to less than 1% in 2000. The water quality class Ⅲ and Ⅳ dropped by 10.2% and 6.7% respectively. The part of class Ⅴ and Ⅴplus increased correspondingly by nearly 30%. In 1998, several measures were implemented to limit the output of pollutants from industry. They

lead to an improvement of the water quality of some rivers, reducing the polluted part of the river from 86 in 1996 to 80.6% in 2000.

Table 1: Some agricultural indexes of Taihu lake basin in the past 20 years

Year	Crop sown area(10^4hm^2)			irrigated farmland (10^4 hm^2)	big livestock (10^4)	Livestock small livestock (10^4)	
	cereals	Cash crop	Total			Pig & sheep	Chicken & duck
1980	270	85	356	143	16	1758	37200
1985	238	94	332	142	13	1457	4869
1990	193	66	259	141	12	1285	5912
1995	162	70	228	138	10	1280	6556
2000	151	95	249	132	11	1302	6441

In the past 20 years, water quality of Taihu lake basin aggravated. Investigations that showed that, since 1980, COD_{Mn}, TP, TN increased slowly showing three peak values during this time, which is highest in 1997. Due to the implementation of "zero point " and other pollution control measures in Taihu lake in 1998, the indexes had obviously declined, but began to rise slowly again from 1998 to 2000, especially the values of COD_{Mn} which reached peak values in 1997 and 2000. In 1981, COD_{Mn}, TP, TN were 2.83 mg/L, 0.020mg/L, 0.900 mg/L, but in 2000 were 5.10 mg/L, 0.120 mg/L, 3.012 mg/L, which makes an increase of by 80% , 500% , 234.7% respectively.

From the 80s until now, the water quality of Taihu lake has already dropped by two levels, from class Ⅱ to IV, from mid-nutrition to eutrophication. At present, lake eutrophication and the great outburst of blue algae have already become an environmental problem in Taihu lake.

The gross output of industry has increased 13-fold, with an average annual growth of 14.1% in the past 20 years. The fast development of the industry resulted in an increase of water requirements by $8.01*10^9$ m^3 with a growth rate of 3.4% per year. With the development of technology, the reuse of water increased to some extent, but the total amount of water consumption increased very fast as did the amount of waste water. Meanwhile, the municipal water consumption and sewage increased dramatically due to growing population and higher living standards. The industrial and agricultural wastewater increased from $3.6*10^9$ m^3 in 1987 to $4.9*10^9$ m^3 in 1999 and $5.33*10^9$ m^3 in 2000. The composition of waste water is complicated. It 2000 the CODcr discharged from point sources of industrial and sanitary sewages were 42.8% and 57.2% respectively, NH_3-N accounting for 37.4% and 62.6%. Municipal water pollution was becoming a predominant factor for water degradation. With the increase of population and urbanization, the effects of municipal sewage will be enlarged.

Since 1998, most industrial pollution are effectively disposed and 70%-80% of industrial effluent are controlled because of the increasing investment in environmental protection. However, the current treatment rate of municipal sewage of just below 20% is insufficient and the sewage drainage pipeline systems in cities were in shortage. As a result, only one third of industrial and municipal pollutants were cleaned up, and a great part enters the water bodies. The water quality decreased dramatically.

In order to raise productivity of farmland, some changes were observed in the agricultural land

use mode: the area for cash crops was increasing (see table 1) and lowlands or paddy lands were changed into ponds for aquaculture. These actions destroyed water bodies, filled parts of the rivers and altered the original eco-function of the rivers. It also affected the water quantity and the natural cycling of nutrients and lead to a degradation the aquatic environmental and the diluting power of water. With the economic development, an important change in agricultural mode of production took place: a decrease in the use of organic fertilizer and an increase in chemical fertilizers, pesticides and insecticides. According to statistics, 577.5 kg/hm^2 of chemical fertilizers and 34.5 kg/hm^2,of pesticides were applied, which is far more than the national average of 411 kg/hm^2 and 11.25 kg/hm^2. Additionally, the excessive application of chemical fertilizer and extensive and spray irrigation transport the unused fertilizer into rivers and pollute the water body. Moreover, some traditional and efficient production modes, such as rational shifting cultivation, insolating arable land, applying organic fertilizers and digging river bed mud as fertilizers, are abandoned resulting siltation and pollution.

Aquaculture is another important factor of agricultural non-point pollution. The area of seine breeding and the density of aquaculture had increased since 1980. The residual guano and aquatic excretion intensified the water eutrophication to some extent.

Future trends

Currently socio-economy is expected to grow at a speed of 10%. Until the year 2010, the GDP will reach 2458.5*10^9 Yuan (RMB), the population will be 4.4*10^7 and the rate of urbanization would increase to 77%. The total added value of industry, with a parallel increase of GDP, would keep an annual growth rate of 10%, and approach to 1159.3 *10^9 Yuan (RMB), the total added value of tertiary industry would be 45% of GDP, 1114 *10^9 Yuan (RMB). The arable area and irrigated area would decrease constantly to 158 *10^4 hm^2 and 127.2 *10^4 hm^2 respectively in 2010. Because of the environmental pressure, the number of livestock, pigs and sheep, poultry would decline to 9*10^4, 9.97*10^6, and 5.5*10^7 respectively.

With economic development, the water requirements would increase constantly, and the water quality demand would be much higher. The water consumption for private consumption, ecology and tertiary industry would rise outstandingly. The water requirement for the manufacturing industry would rise slowly and agricultural water consumption would drop. It was roughly predicted that the volume of water would be 4*10^9 m^3 for household consumption, 9*10^{9}m^3 in agriculture (with a possible of 50% certainty), 1*10^9 m^3 in forestry, stockbreeding and fishery. The industrial water consumption would increase slowly to be 17*10^9 m^3 in 2010, which contained 11.4*10^9 m^3 for power plants and 5.5*10^9 m^3 in general industry. Considered eco-environmental water utilization of 2*10^9 m^3, the total water demand would go up to 33*10^9 m^3. Meanwhile, the water supply would decrease seriously, with a deficit of 15.3*10^9 m^3.

Because of the adjustment in industrial structure and the improvement in technology, the indexes of sewage could decreased a little, but the industrial sewage is expected to increase slowly due to the increasing industrial water consumption. Also, the sanitary sewage would put more pressure on water resources because the treatment of sanitary sewage is insufficient and water consumption is increasing due to the increase of population. Agricultural non-point pollution is also expected to increase because of intensification and limited control. Generally speaking, water pollution would increase in a short time. Pollutants from point sources would continue to

grow and discharge from non-point sources will also rise slowly. It would be the very important to control the water pollution from households and from agriculture.

The future aquatic environment in the coastal and riverine area could be improved by investing in water treatment and in management, but the water quality in the watershed in the interior cannot recovered radically because there are many difficulties to transport the sewage and dispose the pollutants. With economic development, some new types of water pollutants could also appear, such as heavy metal, organic pollution and toxic substances.

Conclusion

The sources of pollution have changed dramatically lot over the past 20 years, and the aquatic environment has a strong link to the socio-economic development in the watershed. Before the 1980s, agriculture played a dominant role on environment by increasing the nitrate concentration in water bodies. With the development of urbanization and industrialization, the density of phosphor and COD_{Mn} grow after 1980s. The proportion of sanitary sewage increased also, making the pollution from point sources discharged of sanitary sewage the predominant type of pollutants.

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