Journal of Lake Sciences, Vol. 10, Suppl., 1-12, 1998.

Taihu Lake—A Large Shallow Lake in The East China Plain*

PU Peimin and YAN Jingsong
Nanjing Institute of Geography & Limnology, CAS, Nanjing 210008, China

Abstract: *The outline of Taihu Lake Basin, including the geographical and hydrometeorological characteristics, its main functions and resource-environmental state and problems facing in Taihu Lake were introduced.*
Keywords: *Taihu Lake Outline, Resources and environment problems*

1. Geographical outline of Taihu Lake Catchment

Taihu Lake is one of the famous five great freshwater lakes in China with an area of 2 428 km^2 (water surface area of 2 338 km^2), and mean depth of 1.9 m. Being a typical large shallow lake, it is located between 30°56'-31 ° 33'N, 119 ° 53'-120 ° 36'E. Facing East China Sea, the catchment area of Taihu Lake covers 36 500 km^2, accounting for 0.4 % of China's territory. Seven large and medium cities, such as Shanghai, Hangzhou, Suzhou, Wuxi, Changzhou, Jiaxing, Huzhou and 31 counties are distributed in the catchment with population of 36 million accounting for 3.1 % of whole China's population. The population density reached 980 km^{-2}, and was one of densest area in China. There are 1.77 million ha cultivated land in this area accounting for 1.7 % of whole China, but the agricultural and industrial production value makes up 1/7 of that in whole China.

2. Geomorphologic characteristics of Taihu Lake

Taihu Lake is situated in wide Taihu Plain at an elevation about 4 m above sea level. Its topographic map is shown in Fig. 1, when the water level is 3.0 m above sea level. The main topographic characteristics of Taihu Lake are listed in Tab. 1. To the west and south-west laid the mountain and hills and to the east the alluvial plain. The coasts are eroded and retreated, providing a part of sediment supply. In general speaking, the sediments of Taihu Lake are dominated of clayey silt, silt and silty clay. Some parts of the bottom of the lake are covered by hard loess sediment with a thin layer of soft silt. The underlying harder loess contains some Fe-Mn concretions, with medium diameter of 7-7.87 Φ. The loess bed is about 4-6 m thick and slightly inclines toward the southeast. There is no submerged vegetation on most part of the lake bottom, except

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

in the southeastern big bay--East Taihu Lake, where the bottom is covered by a thick soft silt (the present mud is about 1-2 m thick) and dense submerged plant cover with a sedimentary rate of 2.7 $mm \cdot a^{-1}$. In northeast subbay--Wuli Lake, the lake sediment is similar to that in East Taihu Lake, but because of rapid development of eutrophication in this Lake the historical submerged vegetation disappeared at present.

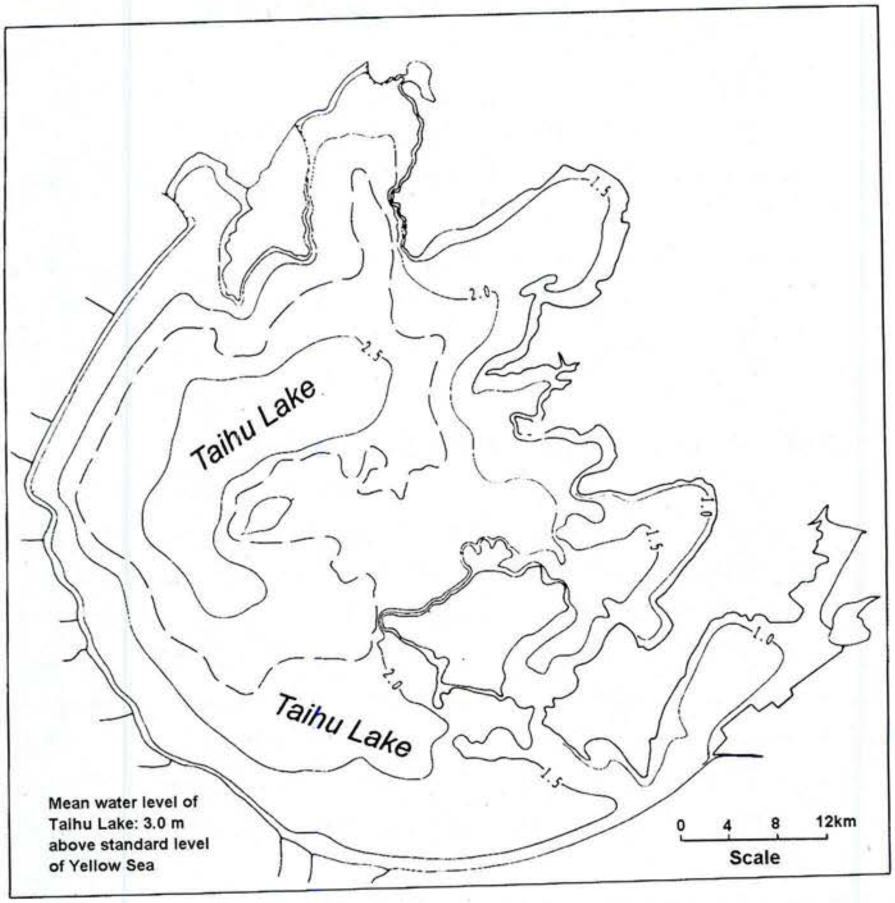

Fig.1 Bathymetric map of Taihu Lake

Tab. 1 Geomorphologic characteristics of Taihu Lake

L. surface (km^2)	2 427.8	Mean width (km)	68.5
Water surf. (km^2)	2 338.1	Mean depth (m)	1.9
Catchm. surf. (km^2)	36 500	Maximum depth (m)	3.0
Catchm. sur, /L. surf.	16.6	Lake volume ($10^8 m^3$)	57.0
L. coast length (km)	405.0	Annual inflow ($10^8 m^3$)	44.3
Length of Lake (km)	68.5	Resident time (d)	283.5

3. Hydrometeorological characteristics of Taihu Lake

Taihu is located in the subtropic monsoon climate zone with a monthly mean air temperature of 28.1-28.7 ℃ in June and 2.5-3.3 ℃ in January, and an annual precipitation of 1 000-1 250 mm, among which 70-80 % are concentrated in period of May-October. The albedo of water surface of Taihu Lake is about 0.15, meanwhile the albedo of surrounding land surface is about 0.35. Because of the large difference in albedo and small difference in evaporation between water surface and surrounding land surface covered mainly by rice field, Taihu Lake is a heat source (Pu, *et al*, 1990). The annual mean water temperature is higher than that of air temperature for 1.3 ℃. The maximum monthly water temperature is about 29.0 ℃ observed in July-August, and the minimum monthly mean temperature is about 4.5 ℃ observed in January. The maximum temperature during 1967-1978 is 38.1 ℃. The cases with whole lake ice cover were recorded 10 times during the last 650 years.

There are 219 inlets/outlets around Taihu Lake recently. The inlets are mostly located in the West part, and the outlets in the East part of the lake. The mean annual total inflow accounts 183 $m^3 \cdot s^{-1}$ with a variation from 0.76 $m^3 \cdot s^{-1}$ in 1978 to maximum of 370 $m^3 \cdot s^{-1}$ in 1954.

In some cases wind driven current were recorded about 80 $cm \cdot s^{-1}$. In a thin layer of 1.5-2 m the current changes their speed and direction along the depth very rapidly. It may cause strong vertical mixing and resuspension of sediment. The concentration of suspended sediment (SS) has a large amplitude of variation (from 0-1 $mg \cdot kg^{-1}$ to 350 $mg \cdot kg^{-1}$ were observed during July to October 1986), strongly related with wave and current conditions. The daily precipitation (P_1, $g \cdot cm^{-2} \cdot d^{-1}$) is a linear function of 27-hourly square root mean wind speed at 10 m above water surface (W_1, $m \cdot s^{-1}$), blowing from the lake during the respective day and 3 hours earlier (Pu, *et al*, 1990):

$$P_1 = a_p + b_p W_1, \qquad a_p = -0.03692, \qquad b_p = 0.05155 \tag{1}$$

The vertical diffusion coefficient of SS $E_s = E_0(y/y_0)$ ($cm^2 \cdot s^{-1}$) may be determined by the 3-hourly square root mean wind speed at 10 m above water surface W_3 ($m \cdot s^{-1}$):

$$E_0 = E_{00} + a_1 W_3 - a_2 W_3^2 + a_3 W_3^4,\ y_0 = 50cm, a_1 = 0.03417, a_2 = 0.00125, a_3 = 0.00928 \tag{2}$$

Water level rapid change causes by wind set-up is a very important dynamic phenomenon in Taihu Lake. The days with evident wind set-up occupy 60 % in a year. The largest amplitude of wind set-up observed during 1986 is 46 cm. The 150 cm of amplitude was observed on January 25, 1949.

Period of seiche in Taihu Lake varies in a quite large range of 2-9 h with a dominate period of 6.7 h and they change in 22 min, when the mean depth of the lake changes in 20 cm. The maximum amplitude of observed seiche is 12 cm and its mean value is 5 cm during 1986. The seiche amplitude decays with time according to the exponent form:

$$A_n^* = \exp(-\nu_n n), \qquad A_t^* = \exp(-\nu_t t), \qquad A_n^* = A_n / A_0, \qquad A_t^* = A_t / A_0; \tag{3}$$

where A_n , A_t and A_0 are the amplitude of nth wave, and at t and initial time, respectively. ν_n and ν_t are the decay coefficients. The mean value of ν_t in Taihu Lake is estimated as $3.28\times10^{-5}\ s^{-1}$.

The mean transparency in Taihu Lake changed in space and time between 0.3-1.3 m. The mean value of transparency of the whole lake in summer, autumn, spring and winter during May 1987-March 1988 are 0.90, 0.57, 0.43, and 0.31 m, separately.

Rapid vertical shear of current, shallow water wind wave, large amplitude of wind set-up and seiche, etc., all these hydrodynamic processes lead to strong vertical and horizontal mixing and resuspension of sediment and other substance in lake. In open lake there are not submerged aquatic plants, the turbidity and transparency change rapidly and the transparency is usually less than 30 cm in strong wind wave condition. There is a well-mixed layer in upper 4-6 cm of sediment core, and the remainder of algae which are rich in the water body are poor in sediment. All these phenomena must be closely related with the thermohydrodynamic characteristics of typical wide shallow lake—Taihu Lake.

4. Main functions and importance of Taihu Lake

Taihu Lake and its surrounding water net system have an area of 6174 km^2, occupying 1/6 of the catchment area. It is a giant basin for storing water. Taihu Lake and its water net system play a giant role in the economic development of the lake catchment.

Because the precipitation is concentrated in May-October, to prevent the hazards of flood and drought in this plain is of extremely importance. The surface water is the essential source for drinking, industrial and agricultural water supply. The annual fish production from the water system accounts 0.20-0.25 million t. The length of water way transportation in this area is more than 1 300 km. Abundant tourism sites are distributed around the lake. Taihu Lake and its water net systems have their major functions in all these above mentioned aspects.

5. Main problems facing in Taihu Lake

5.1 Water resources problems

5.1.1 Frequent floods

The topography of this area is similar to a plate. It is short in grand canals for discharge. The current in river systems has a low speed of 0.1-0.3 $m\cdot s^{-1}$. Therefore, the floods occurred frequently. There were three serious floods (in 1954, 1983, and 1991) during last 40 years.

The maximum precipitation during 90 days accounted 891.9 mm in 1954. The flood occupied an area of cultivated land of 0.532 million ha. The maximum precipitation during 90 days was 820 mm in 1991. An area of cultivated land of 0.433 million ha were covered by flood. The direct economic lost reached US$ 100 million.

Tab. 2 Water balance of Taihu Lake (10^6 m^3)

Period	Inflow			Outflow						
	P	R1	Σ	E	R2	Q	Σ	ΔV	A	R
1977 May-Sep.	2093.4	5317.7	7411.0	1163.9	4347.8	15.4	5527.1	1843	41.0	0.6
Annual	3391.3	7531.6	10922.9	2697.3	8784.2	33.9	10915.4	513	505.5	-4.6
1969 May-Sep.	1491.1	3340.9	4832.0	1362.1	2732.5	6.2	4100.8	748	-16.8	-0.4
Annual	2516.8	6151.4	8668.2	2287.6	6704.0	13.7	9005.2	-504	167.0	1.9
1978 May-Sep.	799.7	1618.4	2418.2	1514.4	966.0	21.9	2502.4	-65	-19.2	-0.8
Annual	1506.4	3054.8	4561.1	2415.6	3067.8	46.6	5530.0	-788	-180.8	-4.0

P= precipitation on lake surface; R1=inflow; E= evaporation from lake surface; R2=outflow; Q= water consumption for agriculture and industry ; V= variable of water storage; A= absolute error; R= relative error

5.1.2. Lack of water resource

The total annual water resource in the Taihu Lake catchment is about 13.7 billion m^3. Because of the dense population, every resident has just the water resource of about 400 m^3 per year in average. In the normal condition there is lack in water resource of 2 billion per year. In the drought years, such as 1971 and 1978, it was lack in water resource of 10-12 billion m^3 for the catchment area.

From an analysis of the precipitation date for the whole basin, three typical water years 1977, 1969 and 1978 are selected to represent high-water, mean-water and low-water years respectively (Yang, 1982). The water budget for these years is given in Tab. 2.

5.2 Water pollution problem

5.2.1 Pollution sources

The economic rapid development both in the urban and rural area in Taihu Lake Region has got rapid and great advance during the last decade, but the wastewater, sewage and polluted water were discharged more and more into the lake as well. Thus the pollutants including nutrient contents in the lake were increasing gradually

According the survey in 1987 to 1988, there were 118 factories in the area along the coast of lake in distance about 8 km. Total of this industrial wastewater contains TN 158.8 t, TP 15.53 t and COD_{Cr} 13 907 t.

The nonpoint pollution sources were mainly the land along the coast of the lake, and precipitation and fallout. Their discharged loading of farmland were N 4 701.6 $t \cdot a^{-1}$, P 84.34 $t \cdot a^{-1}$ and COD_{Cr} 16 922 $t \cdot a^{-1}$.

The subtotal of point pollution sources were TN 13 188.5 t, TP 2 083.97 t and COD_{Cr} 78 055 t; and that of nonpoint pollution sources were TN 7 882.0 t, TP 177.45 t and COD_{Cr} 40 517 t.

5.2.2 Water quality state in Taihu Lake

Tab. 3 The results of synthetic evaluation of water quality in Taihu Lake (1987-1988)

Time	Type Percentage of area (%) I	II	III	IV	V	Mean water quality	Mean pollution material
1987 May	0	28.3	43.5	28.0	0.2	III	(3.00) TP, TOC, KN, NH_3 (COD, BOD)
Jul	8.3	43.7	40.0	6.8	1.2	II-III	(2.48) KN, TOC, TP (NH_3, BOD)
Sep	7.5	24.6	56.3	10.7	0.9	II-III	(2.72) TOC, KN, COD
Dec	0.4	0.6	20.1	78.8	0.8	III-I	(3.78) KN, TP, TOC (BOD)
1988 Mar	0	0	0	87.8	12.1	I-V	(4.12) KN, TP, TOC (NH_3, COD, BOD)

The water quality, physical factors of water body, sediment and biological association were surveyed comprehensively for five times during the period of 1977-1988. The average water quality in 1987-1988 was nearly the standard state, but after September every year it was decaying and till next March it was the worst. On the other hand, the change of water quality took place apparently in the last thirty years, as following, the content of total inorganic nitrogen increased from 0.12 $mg \cdot l^{-1}$ in 1960 to 1.12 $mg \cdot l^{-1}$ in 1987.

5.3 Hydrobiological resources problems

5.3.1 Water quality state in Taihu Lake

Taihu Lake is rich in fish resources. A total of 106 species of fish had been found. They belong to 71 genera, 24 families, and 15 orders. The annual total catch in this lake ranged 5 633-9 841 t in 1953 to 1959; 8 127-11 730 t in the 1960s; 9 790-13 696 t in the 1970s; and 11 605-16 021 t in the 1980s. The general trend of annual total yield of fish was increasing. But there were some problems concerned in fish resources.

It is a problem concerned in the quality of fish stock that the small-sized fish with lower cost was increasing and becoming dominate, while the large-sized fish with higher cost was decreasing. Stocks were decreasing and reducing in their population. Such as, silver carp (*Hypophihalmichthys molitrix*), black carp (*Airistichthys nobilis*), grass carp (*Ctenopharynodon idellis*), black carp (*Mylopharyngodon piceus*), and *Elopichthy bambusa*, were decreasing since the 1950s. These species of fish should migrate to the flowing water environment of the Changjiang

River to spawn and breeds during their spawning season, and their fries, fingerlings and adults migrate to the lake again for fatting. Since 1950 their migration pathway between Taihu Lake and the Changjiang River were broken and stopped by some dams and sluice gates of water conservation built in the 1950s and 1960s. Therefore, their natural recruit population reduced or even lost and their population declined in this lake. Because of the same cause and result as these species of fishes, other migratory fishes which migrate the sea and fresh water, such as, the anadromous fish including sturgeon (*Asipenser sinensis*), reeves shad (*Hilas reevesii*), Pyffer (*Fugu ocellatus, F. obscurs*), a species of anchovy(*Coilia ectenes*), Mullets (*Mugil ecphalus, M. so-iuy*), and some catadromous migration fishes, including eels(*Anguilla japonica*), and crab (*Eriocheir sinensis, Neorynchoplax intronersus*), decreased year after year. Some of them are no longer found. A part of spawning ground of some ecesis fishes such as common carp, crucian carp, were destroyed by reclamation and over-harvest of aquatic macrophytes, thus resulting their natural recruit population and their population reduced also. While some small-sized fish and shrimp were increasing. these species are habituate to live in the open water.

5.3.2 Destruction of hydrophytes

There were 61 species of hydrophytes belonging to 49 genera and 29 families in the lake before the 1980s. The species number increased one, because we had introduced a species of submerged plant, *Elodea nuttalli*, to this lake in 1986. The area and total production of hydrophytes greatly decreased. Since the 1950s, a total of 161 km^2 of littoral and sublittoral zone with abundant aquatic plants were reclaimed. In West Taihu Lake, in 1981 the total area of emergent hydrophytes only remained 11.12 km^2 occupying about 0.49 % of the area of this lake district with average biomass of 6.9 $kg{\cdot}m^2$ (July 1981) and 76 728 t of total annual production. The area of emergent vegetation were reeds (*Phragmites communis*) and wide rice (*Zizania latifolia*) extending to a water depth of 1.4 m, but their area was continuously decreasing because of the interference from new built stone bank or dam protection almost entirely covering the shoreline of this lake district. The submerged vegetation was only kept in a few part of this lake district in 1981, such as, about 500 hm^2 of *Vallisneria spiralis* pure community in Zhushan Bay in North west corner of West Taihu Lake, with about 0.4 $kg{\cdot}m^{-2}$ of average biomass and 2 000 t annual production; About 300 ha of mixed communities of *Vallisneria spiralis, Hydrilla verticillata, Potomogeton malainus, Eleocharis dulcis and Myriophyllum spicatum* with 3.32 $kg{\cdot}m^{-2}$ of average biomass and 10 000 t of annual production were scantily scattered a few part of this lake district. The total area of submergent plant in West Taihu Lake was 800 hm^2 occupying 0.39 % of the total area of the water-surface of this lake district. Their total annual production was 12 000 t. Because of the over-harvest of aquatic macrophytes to gain the green feeds for cultured fish in ponds, domestic fowls and pigs, and organic fertilizer; especially over-catching of snails and Cobicula on the bottom by using pump dredger in large area of this lake district which seriously destroyed the submerged vegetation. In addition, the decrease of transparency with the aggravation of eutrophication resulted in submerged plant were decreasing year after year, most of submerged vegetation are no longer found in some areas of this lake district which were originally abundant with submerged vegetation. In East Taihu Lake, although about 25 km^2 of littoral and sublittoral zones had been reclaimed since the 1950s, about 40.2 km^2 of emergent vegetation including 3 467 ha of wide rice and 533 ha of reeds were remained still, which occupy 29.6% of the area of this lake district. The biomass of wide rice and reeds were 5.24 $kg \cdot m^{-2}$ and 3.57 $kg \cdot m^{-2}$ and their annual total production were 181 000 and 20 000 t respectively in 1990. The total area of submerged vegetation remained 93.34 km^2 occupying 69.11 % of the area of East Taihu. The area of submerged vegetation communities decreased to 7 main species in 1988 from 12 main species in 1981 (Yan *et al*, 1993). Among them, the dominate species were *Vallisneria spiralis, Potamogeton malainus, Hydrilla verticillata* and *Myriophyllus spicatum.*

The incident rate (frequency) and average biomass of most species of submerged vegetation and each of them occupying the percentage of total biomass of submerged plants had some change in 1988 comparing with that of in 1981 (Tab. 4). This shows that the dominant species, *Vallisneria spiralis and Potamogeton malainus* were increasing and enlarging in their distribution, biomass and production. Their annual production was about 9 334 t in 1990. The great amount of hydrophyte biomass and production prohibited the phytoplankton as they compete with phytoplankton in light, nutrient and space, in addition, some species of hydrophyte can secrete some inhibitor to phytoplankton. So that biomass of phytoplankton in this lake region was much less than that in other districts of Taihu Lake. A total of about 278 000 t of aquatic macrophytes, or 49 % of annual total production of these plant in East Taihu Lake were harvested and transferred every year to the land from the lake to use as green fodders for cultured fish in the ponds, domestic flows and pigs, and some raw materials for building organic fertilizer and fuel. Through this way, about 917 t of nitrogen and 137 t phosphorus were removed out this lake. In addition, about 279 900 $t \cdot a^{-1}$ of aquatic macrophytes or about 48 % of their annual total production in this lake district were grazed by natural and stocked fish. Through the catch of fish indirectly transferred much nitrogen and phosphorus to land from this lake. This resulted in the contribution for to the improvement of water quality as well as increasing much economic benefits. But, in a piece of littoral area near by east coast of East Taihu Lake, there were about 1 400 ha of dense wild rice which grew luxuriant with great natural production without harvest and utilization, and in emerge of itself and perish of itself run its course in this region. After the autumn every year, great deal of remainder defunct wild rice and some companion aquatic weeds were deposited and decomposed on the bottom in this region. It resulted secondary pollution and made the water became black and foul smell with high concentration of COD, BOD, nitrogen and phosphorus, and deficient of dissolved oxygen in about 2 200 ha of lake region in this lake, when the temperature raised (Zhang, 1993). This lesson teaches us that to keep the material balance is very important for protection of lake. The reasonable utilization of hydrophyte is a way and measures for protection of lake. Otherwise, single and simple conservation of hydrophyte without reasonable utilization, or over-harvest and excessive utilization not only can not protect the lake, but also destroy it.

Tab. 4 Frequency, average biomass of submerged plants in East Taihu Lake

Species	Incident rate(%) Average biomass		Average biomass (kg·ha^{-1})		Percentage of verage total biomass	
	1981	1988	1981	1988	1981	1988
Vallisneria spiralis	95	100	134	332	27.5	48.0
Potomogen malainus	64	70	122.5	22	25.2	32.9
Hydrilla verticillata	74	93	64.0	68	13.1	9.9
Myriophyllum spicatum	45	60	37.6	30	7.7	4.4
Ctratophyllum demersum	10	30	7.3	2	1.4	0.3
Char						
Heleocharis yokoscensis	36		49.0	30	10.0	
Eleocharis dulcis	14		1.8		0.5	
Potamogeton pusilus	12	70	18.6		3.8	4.3
Utricularis aurea	1		0.9		0.2	
Najas minor	19	5	7.7	0.3	1.7	
Potamogeton crispus	1		3.2		0.6	
Total mean	40		487.4	698.3		

5.3.3. Excessive increase of phytoplankton

In whole Taihu Lake, a total 114 species of phytoplankton had been found in 1981. They belong to 8 Phylum including Cyanophyta (17), Cryptophyta (2), Pyrrophyta (4), Chrysophyta (3), Xanthophyta (20), Bacilarophyta (25), Euglenophyta (6), and Chlorophyta (55), in 1988, only 97 species of algae in plankton were found, 22 species were no longer found which had occurred in this lake in 1981. Since 1990, in the survey at 41 sites in whole lake for 6 times every year during four years, only 88 species of phytoplankton were found. The predominant species were *Microcystis aeruginos*, M. *flose-aquae*, *Anabaena spirodes*, A. *flosa-aquae* of *Cyanophyta* comprising up to 70% of total phytoplankton. They mainly distributed in the north and northeast districts of the lake, and usually formed water bloom from March to November every year since the 1980s. Some data on the average biomass of phytoplankton in different districts of Taihu Lake were shown in Tab. 4. Their mean annual biomass was increasing (Tab. 5). The quantity of phytoplankton in 1981 was 46.7 times more than that in 1960 with an increase especially of *Microcystia* and *Anabaena*, and was about a half of that in 1988. The peak of phytoplankton had been found in 13.2 billion cells·l^{-1} and more 109.2 mg·l^{-1} in the summer 1990, in Meiliang bay, N.E. part of the lake. The increase of phytoplankton may be taken as an indicator for eutrophication, which is a characteristic as the lake exhibiting progressive eutrophication and to eutrophic water body.

Tab.5 Average annual biomass(mg·l^{-1}) of phytoplankton in various districts of Taihu Lake

Lake district	1981	1988	1991	1992	1993
Wulihu Lake	9.21	25.10	24.26	11.30	18.41
N. and N.E District	4.46	8.19	5.74	6.94	7.37
Others	3.07	6.65	6.10	6.12	3.17
Wast Taihu Lake	3.36	3.54	2.88	3.32	2.83

The spatial distribution of phytoplankton biomass was that maximum values were recorded in Wulihu Lake near by the north bay and Meiliang bay in north-east part of the lake, with 82 million cells·l^{-1} and 24.26 mg·l^{-1} of annual mean biomass of phytoplankton in 1990. The concentration of phytoplankton in the lake water reduced the water quality. In July 1990, a large area of water bloom formed with 13.2 billion cells·l^{-1} and 109.2 mg·l^{-1} at the surface of phytoplankton biomass; and 4.8 billion cells·l^{-1} and 43.8 mg·l^{-1} at the water depth three meters below; 5.9 billion cells·l^{-1} and 48.5 mg·l^{-1} at the water depth one meter in Meiliang Bay, which one of the intake area of Wuxi City Drinking Water Supply Plant located. In that time, this water supply plant was forced to reduce its water supply by more 50 % because the filtering ponds of that plant blocked up and the counter-flushing increased, whereas the water consumption requirement peaked during hot summer. About 300 000 inhabitants had trouble in getting tap water. The curtailment of water supply forced 116 factories to stop or partly stop produce one after another for about one week in July 1990. The direct economic loss was estimated to be RMB 130 million. The normal life of the inhabitants in Wuxi City was seriously disturbed.

5.4 Eutrophication problem in Taihu Lake

5.4.1 Assessment of trophic state of the lake

According the assessment method of modified Carson's Trophic State Index (TSIm), based on the surveyed date in 1977 to 1978, the whole lake was evaluated to eutrophic state, but it was different in various districts and seasons. The East Taihu Lake and the central district of the lake were in meso-eutrophic state, but while Wulihu Lake, Mailian Bay and North-South District of the lake were in eutrophic state, even hyper-eutrophic state.

5.4.2 Influences of eutrophication on the economic development in the lake catchment

Eutrophication of Taihu Lake leads to decrease in species diversity, plant and animal biomass, transparency and total water quality.

Taihu Lake is an important drinking water source and one of the major recreational attractions for China. Tourism, swimming, sporting fishing and boating are highly popular pastimes in this lake. The excessive increase of phytoplankton reduced the amenity of the lake landscape. It decreased the transparency and made abominable water colour and smell and can not be use as the source for drinking water treatment, can not be fit for swimming. It disturbed the pen and cage fish culturing some lake districts where a large area of water bloom formed frequently, such as the stocked fish in the enclosure in Sanshan Lake died soon after stocking since 1990 because of the high concentration of NH_4^+-N and deficiency of DO from decomposition of great amount dead algae. Eutrophic problem became a limitation factor for sustainable economic development in the Taihu Lake Catchment.

6. Urgent task for solving the problems

A serious research and engineering projects, and management measures have been doing for solving the above mentioned problems since 1960s, and enhancing since 1980s. The Taihu Basin Authority was established in Shanghai for integrate management of the Lake Basin.Taihu harnessing, as an urgent task for solving its problems is one of the three major lakes harnessing projects of state importance in China at present.

References

Chen, S. 1990. Fish and its role in substance circulation in water body, Ecological Study in Lake Donghu, Science Press, Beijing, pp. 292-378.

Jin, Xiangcan *et al.* 1995. Lake Environments in China, Tom II, Oceanography Press, Beijing, pp.108-149.

Nanjing Institute of Geography, 1982, Lakes in Jiangsu, China, Jiangsu Science & Technology Press: 132-149.

Pu, P. *et al.* 1987, Abstracts of International Symposium on Lake Tai and Lake Biwa. Nanjing, pp. 3.1-4.

Pu, P. *et al.* 1990. Thermohydrodynamic characteristics of Tai Lake in China and their environmental effects. *Verh. Internat. Verein. Limnol.*, 24: 102-106.

Pu, P. *et al.* 1991. Progress of limnology in China, *Chinese J. of Oceanol. and Limnol.* 9: 193-206.

Pu, P. *et al.* 1993. An experimental study on the physic-ecological engineering for improving Taihu Lake water quality in water source area of Mashan drinking Water Plant. *J. of Lake Sciences.* 5: 171-180.

Pu, P. *et al.*1993. Physic-Ecological Engineering for improving Taihu Lake water quality in intake area of Mashan Drinking Water Plant. Proc. 5th Intern. Conf. on the Conserv. and Manag. of Lakes. Italy, pp. 480-483.

Pu, P. *et al.* 1997. A Physico-Ecological Engineering experiment on purifying water quality in a hypereutrophic bay of Taihu Lake,China. (XXVI SIL Congress, Sao Paulo, Brazil, July 23-29, 1995), *Verh, Internat. Verein. Limnol.* 26: 756-759.

Pu, P., Hu, W., Pang, Y., *et al.* 1997. A physico-ecological engineering experiment for purifying raw water quality in a lake.*J. of Lake Sciences*, 9: 150-157.

Sun, S., Wang, Y., *et al.* 1993. *Taihu Lake,* Oceanography Press, Beijing, pp.250-261.

Tu, Q. and Pu, P., 1991. Current situation and changing tendency of water pollution in main lakes of China, *Verh. Intern. Verein. Limnol.*: 1081-1085.

Wang H., Du, H., *et al*, 1989. Lake Resources in China, Science Press, Beijing, 250pp.

Wu, J., *et al*, 1990. The comprehensive control of West Lake in Hangzhou City and its change of trophic state, Eutrophication of Lakes in China, Beijing, pp. 469-500.

Yan, J. & Ma, S. 1991. The function of ecological engineering in environmental conservation with some case studies from China, Proc. Intern. Conf. Ecological Engineering for Waste

Water Treatment, Sweden, pp. 80-94.

Yan, J.S., Zhang, Y.S., & Wang, M.Z. 1987. The estimation of fish potential production and some proposals for rational utilization and development in lake Coahu, *Rural Eco-Environment*, 3: 34-41.

Yan, J. S., Zhang, Y. S., Zhou, W. P., Yin, Y., & Shu, D. 1988. Studies on various ecological forms of Lakes and reasonable utilization for resources of aquatic products and protection of lakes in Lake Taihu Region. In: Nanjing Institute of Geography & Limnology, Academia Sinica (Ed.). Study on long-range prospect of water-and resources and development in Lake Taihu Region. Science Press, Beijing, pp. 94-112.

Yan, J.S. & Zhang, Y.S. 1989. Bio-resources of Lakes. In: Wang, H. D., H.S. Dou, J. S. Zhang & J.H. Su (Ed.) 1989, Resources of Lake in China Publ. House, Beijing, pp. 36-86.

Yan, J.S. & Ma, S.J. 1991. The function of ecological engineering in environmental conservation with some case studies from China. Proc. Intern. Conf. Ecological Engineering for Waste Water Treatment, Sweden, pp. 80-94.

Yan, J.S. & Zhang, Y.S. 1992. Ecological techniques and their application in China, *Ecol. Eng.*: 261-285.

Yan, J.S., Zhang, Y.S. & Wu, X. 1993. Advance of ecological engineering in China. *Ecol. Eng.*: 193-215.

Zhou, W, *et al*, 1988: A study on the fertile efficiency on rice using water blooms of blue-green algae as manure, *Oceanologia et Limnologia*, 19: 125-132.