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On the Problem of the Eutrophication of Taihu Lake and Its Countermeasures of Comprehensive Control*

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Abstract: *On the basis of nine-time current situation investigation for eutrophication of Taihu Lake during 1991-1995, this paper evaluated the trophic levels in the different periods and analyzed the development of the main nutrient content in the nearest 35 years. The results show that the trophic level of Taihu Lake is in the transition state from meso-eutrophic to eutrophic. The eutrophhic and hypereutrophic waters account for 10 % or so. The limiting nutrient, P, rises most rapidly, which causes the ratio of N:P to decrease. The increase of P content is still one of the main factors giving rise to the eutrophication of Taihu. Lake*

Some proposals of comprehensive countermeasure for the eutrophication are put forward. They include the pollution source control of the basin, the littoral multiple management, optimal dispatch of water conservancy facilities, the engineering of helping Taihu Lake with diversion of the Changjiang River, and as well as the setting of the water quality protection and legal system.
Keywords: *Lake Taihu, eutrophication, history and current situation, comprehensive control*

1. Introduction

Taihu Lake is one of the five famous largest freshwater lakes in China, with an area of 2 338 km^2 and a depth of 2-4 m. For the last decade, the economic development and lake resource utilization have made a mighty advance, however the water pollution control lagged behind. At present the water environmental pollution, especially in eutrophication, becomes a more serious problem.

Eutrophication is a phenomenon that the primary productivity in waters gradually transits from low oligotrophic to high eutrophic state because accumulate excessive nutrients in lake. The productivity development in waters may be relation with individual nutrients in certain period, especially with a limitng nutrient. Based on the knowledge from achievements in lake studies during last years, people more and more understand that the trophic type of a lake not only is determined by the individual nutrient elements, but also should be the comprehensive reflection in chemical, biological and physical indexes, when the content of the limiting nutrients be in the extent.

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2. Methods

According to this idea, Carlson S.E. put forward a method, named TSI (Trophic State Index) in 1997. He took transparency (SD) as criterion, and derived the correlation of chlorophyll-a (chl *a*) and total phosphors (TP) with SD. Thus TSI responding to chl *a* and TP were obtained and used to evaluate the eutrophic status of a lake. Morihiro Aizaki took Chl *a* as criterion to modify the TSI (TSI_M), which correlated the chemical, biological and physical parameters of water quality with the eutrophic status to reflect the feature of comprehensive evaluation. It was proved to be useful method for quantitative evaluation. J φ rgenson S. E. combined the feature of water with the viewpoint of limnologial ecology to work out the standards for eutrophication of lakes.

In order to evaluate the eutrophication of Lake Taihu, this paper drafted the evaluating standard for eutrophic status of Taihu Lake (Tab. 1), which was on the basis of the standard from Morihiro Aizaki and choose chl *a*, SD, TP, TN, chemical oxygen demand (COD) and phytoplankton dominant species.

Tab.1 The evaluating standard for eutrophication of Lake Taihu

Score	trophic type	Chl-a ($\mu g \cdot l^{-1}$)	SD (m)	TP ($\mu g \cdot l^{-1}$)	TN ($mg \cdot l^{-1}$)	COD ($mg \cdot l^{-1}$)	phytoplankton dominant species
10	ultro-oligtrophic	0.10	15.0	0.9	0.02	0.24	------
20	ultro-oligtrophic	0.26	8.0	2.0	0.04	0.48	------
30	oligotrophic	0.66	4.4	4.6	0.08	0.96	Chrysophyta
40	oligo-esotrophic	1.60	2.4	10.0	0.16	1.80	Chrysophyta
50	mesotrophic	4.10	1.3	23.0	0.31	3.60	Pyrrophyta
60	meso-eutrophic	10.00	0.73	50.0	0.65	7.10	Bacillariophyta
70	eutrophic	26.00	0.40	110.0	1.20	14.00	Bacillariophyta, Cyanophyta
80	hyper-eutrophic	64.00	0.22	250.0	2.30	27.00	Cyanophyta, Clorophyta
90	ultro-eutrophic	160.0	0.12	555.0	4.60	54.00	Abnormal organisms

Taihu Lake has several sublakes. They are Wulihu Lake, Meilianghu Lake and Dongtaihu Lake. Forty-one sampling stations are located in Lake Taihu. The data were mainly collected during 1991-1995. The surveys and investigations are 6 times per year. Thirty-three physical, chemical and biological items were analyzed. All mean data were weighted average by area.

3. Results and Discussion

3.1 Distribution of algae bloom and change of algae biomass

According to the investigations and some historical data, a great change of water quality in Taihu Lake have been taken place since 1950's. There was no algae bloom on the whole lake in 1950's. Ten years after, small algae bloom appeared incidentally in Wulihu Bay, Taihu Lake. The bloom area in 1970's was slightly larger than that in 1960's,. Entering 1980's, the distributions of algae bloom were obviously wider and wider, and the increasing speed is distinctly rapid. And the distributions of the bloom are agreeable to those of the eutrophic. Secondly, on the basis of alga

analysis, the number and biomass of the algae in Taihu Lake are rising with the time in the recent years (Fig. 1). At the same time, the nutrient contents have being rapidly gone up as well. Since 1987, TP and TN contents have clearly increased. These phenomena indicated the deterioration of water quality and the development of eutrophication.

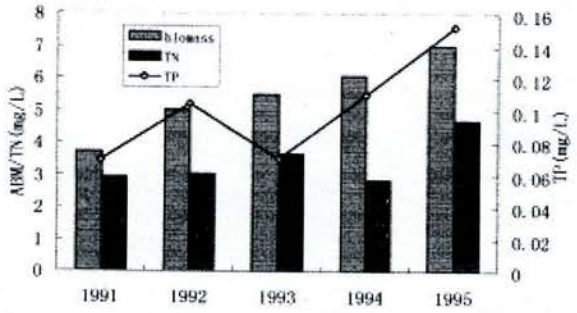

Fig.1 The variations of algal biomass(ABM), TN and TP in Taihu Lake (1991-1995)

3. 2 Spatial and temporal distributions of the eutrophic situations

Based on the actual survey data collected during 1987-1995, we comprehensively evaluated the trophic types ofTaihu Lake according to Tab. 1. The distributions of trophic types in different seasons are drawn in Fig. 2.

From Fig. 2, we can see that there are five trophic types in Taihu Lake during 1987-1995, namely oligo-mesotrophic, mesotrophic, meso-eutrophic, eutrophic and hyper-eutrophic. Most part of the lake belongs to mesotrophic, accounting for more than 70 percent of the total lake area. It was distributed mainly over the open lake, south and east part littorals. The distributions of the mesotrophic and eutrophic waters came secondly. The mesotrophic area was principally distributed in Dongtaihu Bay and the east littoral. The eutropphic occupied the north part of lake (Meilianghu Bay and Wulihu Bay) and the west littoral, making up 10 percent of the total lake. The distribution of eutrophic type is mainly affected with distributions of city and inflow rivers. The oligotrophic and hyper-eutrophic are two extreme trophic types. The former chiefly appeared in Dongtaihu Bay, and the latter only did on the local waters of Meilianghu Bay m June 1994. As the whole, the trophic level of Taihu Lake is still in transition status from mesotrophic to eutrophic.

In order to get the trophic situations of Taihu Lake and its main bays, we still take 6 items to evaluate the trophic levels by means of scoring. Fig. 3 shows the changes of the eutrophic levels of Taihu Lake and its main sublakes in summers in 1981-1995. On the average, Wulihu Bay and Meilianghu Bay have almost entered in eutrophic situations since 1990, and however it was meso-eutrophic in 1981.It leaps one trophic class within 13 years and the recent tendency is more clear. On the other hand, the whole Taihu Lake is approaching to the eutrophication. Although the trophic level of Taihu Lake is still in transition stage from mesotrophic to eutrophic, the notable change in the recent years will give us a serious warning. There are indications that, at present, eutrophication is the main question of the water environment in Taihu Lake.

3. 3 Relationships between nutrients and eutrophication

From Fig. 3, we can see that TP have good relationship of synchronous increase with alga amount (Chl-*a*). However, TN also has similar relationship with Chl-*a*. Then, we have to ask this question: which is the limiting nutrient? The ratio of N to P in the lake could give me partial answer. During 1987-1995, the ratios were 10.4-91, mean value is 35, and much larger than 8-10. Namely they express that phosphorus is the limiting nutrient from field data. TP in Taihu Lake is in higher level now. The mean content range in 1995 is 25-104 $\mu g \cdot l^{-1}$. That is, it is almost larger than eutrophic critical value (20 $\mu g \cdot l^{-1}$).

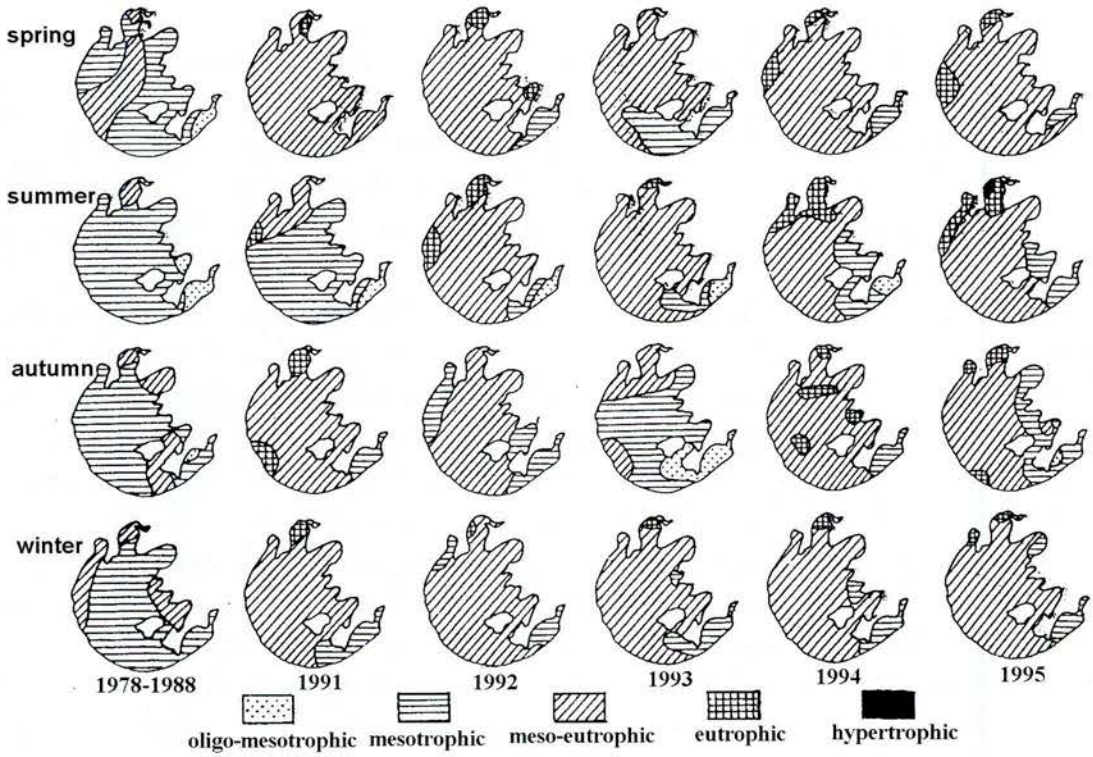

Fig. 2 The trophic levels ofTaihu Lake in different seasons during 1978-1995

Limiting nutrient element, e.g. P, is a very important factor without sole factor in development of a eutrophic lake. A lake trophic state is involved in many natural and artificial factors.Taihu Lake is like a shallow dish. Its mean depth is only 2m. The Taihu basin area holds 39 million people now. Human effect on the waters expresses specially obviously. In 1987, phosphorus loading into lake are principally residents, livestock, precipitation and farmland. It is obvious that the amount of the pollutants entering Taihu Lake is increasing during 1980-1995 from some pollution sources (river, tourism, pen culture and precipitation), of which the rivers input twice pollutant

amount in 1995 as that in 1980, and the tourism rose 6.89 times during 1980-1995.

Here we put forward a general idea for controlling the eutrophication of Lake Taihu. In order to decrease the eutrophication ,we must control P and N into the lake. Firstly, the countermeasure program is considered in three different scales, namely, basin, littoral district, and inner-lake. In the whole basin region, we should gradually control industrial and living sewage discharge, and build up sewage treatment plants. Meanwhile the nitrogen and phosphorus loss from farmlands are also controlled. For the littoral district, main polluted rivers are key controlled objectives, such as Zhihugang River, Dapuhe River and so on. Another important thing is popularly using P-free detergents. In the respect of inner-lake comprehensive control, there are three things to be urgently done. They are sludge dredging, rebuilding macrophyte, and purification engineering. Some of these projects have been tested in the local waters.

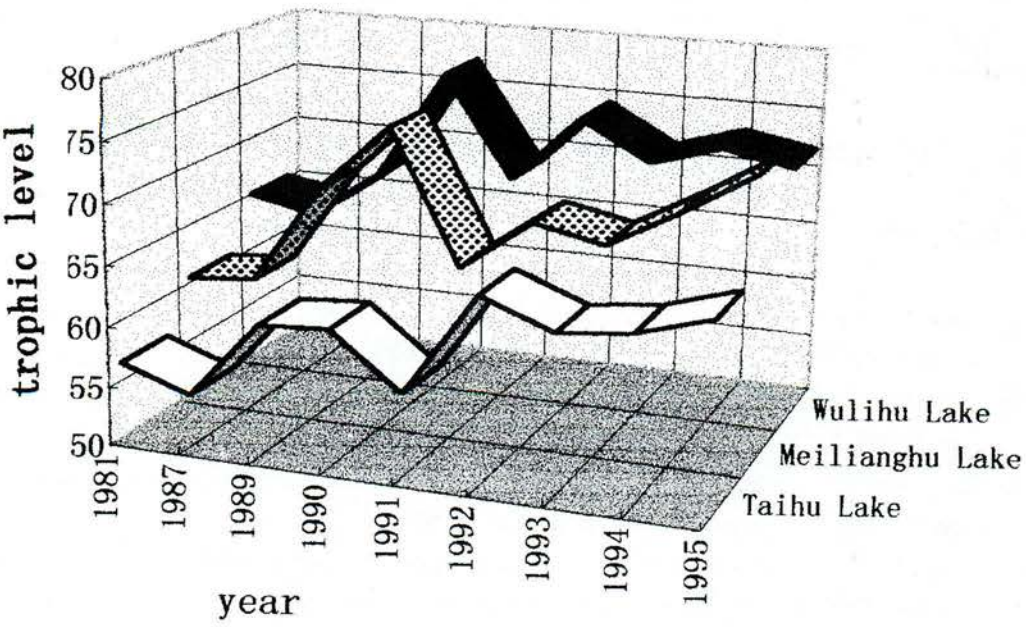

Fig. 3 The trophic levels of Taihu Lake and its main bays in summers during 1981-1995

Tab.2 The comparison of the relative pollutant quantity of the main pollution sources

	1980	1987	1995	reference
river	1.00	1.34	2.04	COD
tourism	1.00	3.39	6.89	COD
pen culture	----	1.00	3.36	TP
precipitation	1.00	2.23	3.10	NH4+-N

The eutrophic problem of Taihu Lake is very serious now. So long as our countermeasure pro-

grams and work are well-done, the ecological environment may be restored in the future.

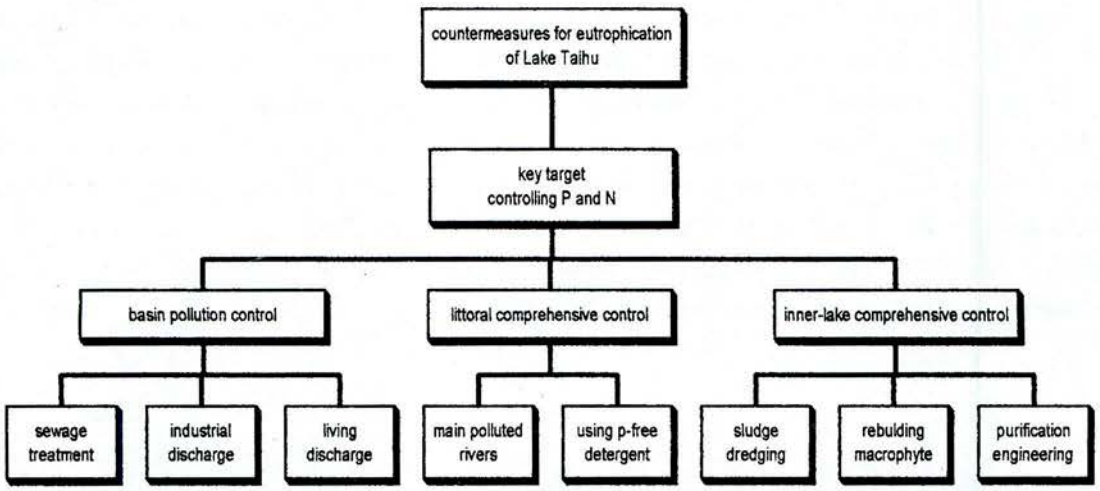

Fig. 4 The comprehensive countermeasures for the eutrophication of Lake Taihu

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