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Regional eco-environmental analysis of Yuxi River–Chaohu Lake

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Abstract—Yuxi River–Chaohu Lake water suffers greatly from the ecological problems of eutrophication, high turbidity, organic pollution, disappearance of littoral macrophyte, bank erosion and reduction of economic fishery products. With *Microcystis* dominant, it is a degenerated and weak ecosystem. Its vicious cycling is caused by too much nutrient load, high spring water level and improper management of the water. The point sources of pollution from cities and industries contribute more than 50% of nutrient load. Soil erosion and fertilizer loss from late rice fields are important factors in non-point nutrient load. The disappearing littoral zone can neither give enough protection for the bank nor provide proper habitats for the biota. The feasibility of " ecological water level proposal" and means to reduce nutrient load are discussed to improve the habitat environment for both the nature and human being.

Keywords: Yuxi River; Chaohu Lake; eutrophication.

INTRODUCTION

Yuxi River is a downstream tributary of Yangtze River (Fig. 1) with a catchment area of 1300 km^2 in Anhui Province, China. Chaohu Lake lies in the middle of this river. In recent decades, the aquatic ecosystem has been in a poor condition and natural resource is damaged by improper human management and exploitation.

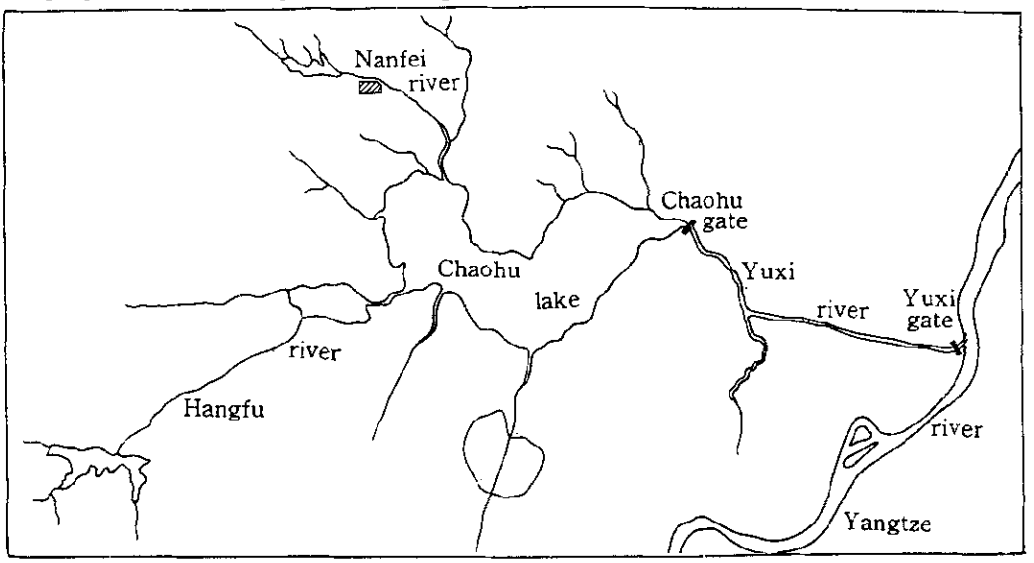

Fig. 1 Geographical location of Yuxi River and Chaohu Lake

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The main ecologic–economic functions of this water body are: boat transportation, city water supply, aquaculture, agricultural irrigation, recreation and regulation water with Yangtze River. Since 1960, these functions have been impaired because of the increasing impact from human activities. The construction of two water gates, which are on downstream Yuxi River and has artificially isolated this water body from Yangtze River, has been the most important factor. Many ecological problems occur in the water body.

DETERIORATED ENVIRONMENT

Eutrophication of the water is the greatest impairment for the functions. Algae bloom (mostly *Microcystis*) can be observed in the lake in about 80% of the days from late May to middle November. That is notorious nuisance. The pollution caused by algae bloom is a dangerous problem for city water supply. It not only plugs the filter beds and increases the frequency of backwash, but also reduces the quality of the supplied water.

Another problem is the high turbidity of the lake water which contains large quantity of suspended solids. It decreases the light intensity in water and inhibits the photosynthesis rate of algae in the middle and lower layers, thus makes blooming algae more dominant in the aquatic environment.

The third is the organic pollution. Organic matter from algae decomposition and from untreated municipal and industrial waste water is of high concentration. It partly enters the water plant and effects the drinking water quality.

The fourth is the lack of macrophyte along the lake shore. The submersed and emersed plants disappeared in the most part of the littoral belt in early sixties, causing the fifth ecological problem, i.e. bank erosion. According to previous investigation (Anhui Institute for Environmental Protection , 1986), there was 44 km of lake shore with serious erosion and 20 km with slight erosion, which made 340,000 m^3 soil (500,000 ton) enter Chaohu Lake and caused the land loss of 240 mu (16 hectares) per year. Besides the lake, many parts of upstream and down stream of Yuxi River also suffer from bank erosion. The land loss aggravates the population stress in the area.

The sixth is the decline of quality and quantity of economic aquaculture products. The productivity of high–valued fish decreased 78% in 1980 in comparison with that in 1952. *Coilia ectenes* Jordan et Seale, with very low economic value, has become the dominant fish species in Chaohu Lake.

The biota has changed greatly in Chaohu Lake since 1960. Besides the disappearance of emersed and submersed plants, herbivorous fish and detritus feeders declined, secondary carnivores also reduced and primary carnivores (zooplankton feeding fish) became the dominant fish species. *Microcystis* is the majority of the biomass. This biota forms a weak food chain with most primary productivity unable to convert into secondary in an efficient way. The ecosystem of Chaohu Lake (Fig. 2) is simple with few species and lack of their interactions.

AN ECOLOGICAL VICIOUS CYCLE

The eco–environmental deterioration in Yuxi River–Chaohu Lake is caused by various reasons. The Yuxi River water can be roughly divided into 5 subsystems (Fig. 3): agricultural subsystem; city subsystem; subsystem of upstreams and ponds; lake subsystem and Yuxi River downstream subsystem. In the fifties, the natural matter and energy exchange strengthened the relationship among the subsystems. The matters from the catchment mainly enter the lake through upstream tributaries. The city subsystem obtains water from the lake. The agricultural subsystem takes water for irrigation. There are flows and back flows among Chaohu Lake, Yuxi River downstream and the Yangtze. According to hydrological record, the average runoff from Chaohu Lake watershed was 3030 million m^3/a and the average back flow from Yangtze River used to be 1360 million m^3/a before 1959. The ratio was 1:0.45. Chaohu water gate and Yuxi

water gate were built in 1959 and 1962 respectively. Since then the average runoff from the watershed has been 3490 million m^3/a, and back flow 160 million m^3/a with the ratio of 1:0.05. The decrease of water exchange made Yuxi River and Chaohu Lake a semiclosed water body. Meanwhile, several large reservoirs and many small ponds were constructed in upstream of Yuxi River and the relation between agricultural subsystem and the river is also controlled by human activities. Thus the entire water body has almost become an artificial impoundment.

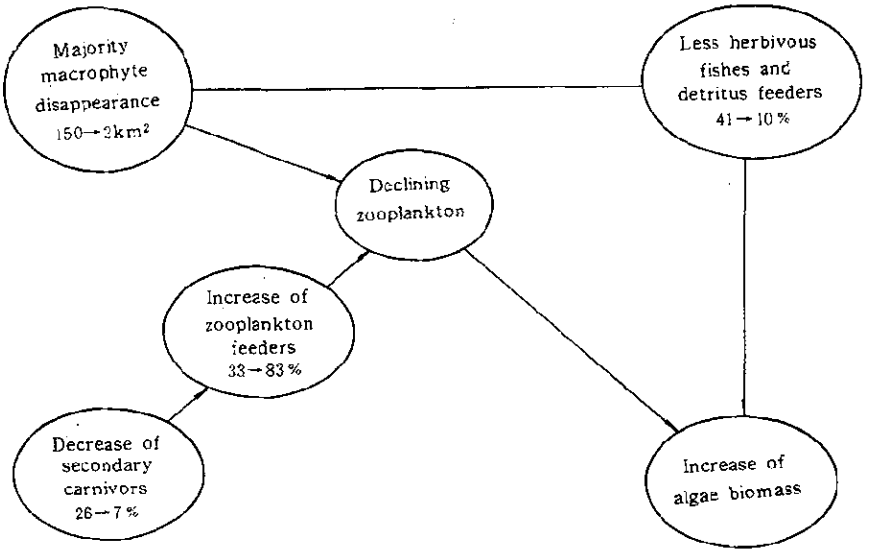

Fig. 2 The effects of changes in trophic level and habitat on algae biomass

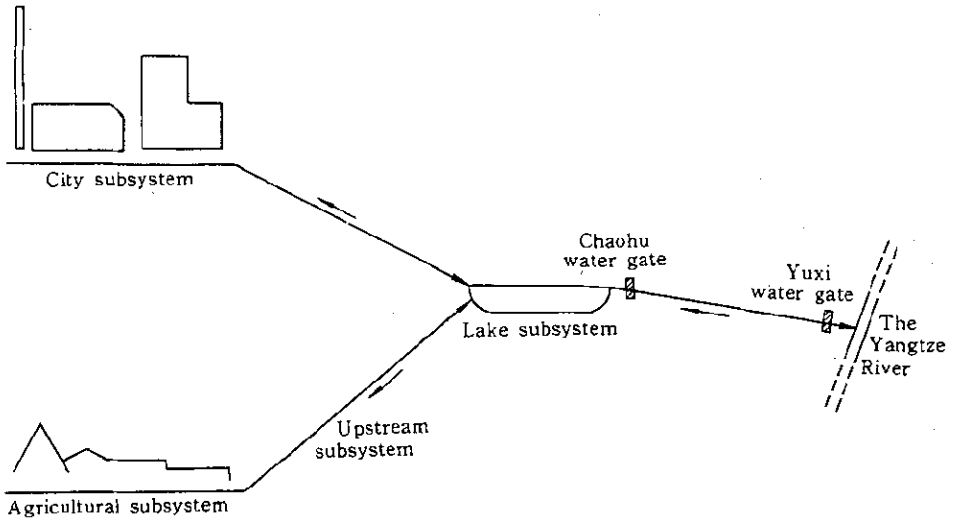

Fig. 3 Relationship among subsystems of Yuxi River-Chaohu Lake regional ecosystem

People used to manage the artificial ecosystem according to their own ideas and short term benefit, which sometimes is against the law of the nature. In the past 30 years, the water were

controlled only according to the requirement of boat transportation and agricultural irrigation. The water level was kept too high. In 1950s, the spring water was about 6.2 m sea level and there was emersed and submersed vegetation of 150 km^2, about 20% of the lake area. But during 1962 to 1983 after the water gate was built, there were 8 years in which the spring water level topped 7.8 m and the littoral zone almost disappeared with the majority of macrophytes unable to sprout and killed. The vigorous emersed vegetation disappeared. Another consequence of this is to block the exchange of aquatic organisms between the Yangtze River and Yuxi River including Chaohu Lake. Fishes enter the lake through the exchange of water. There used to be 460–1500 million m^3/a flow from the Yangtze and it was estimated that there were about 100 fish fries per cubic meter in spring water which provided Chaohu Lake large quantity of silver carp and other economic fishes. After the gates were built, the biomass of silver carp and migrating fishes declined tremendously. Although there are fish migration channels on the two water gates, they are often blocked. Besides, there are two chemical plants on each side of Yuxi River just downstream of the Chaohu water gate and the waste water discharges into the river directly. The diffusion and degradation rate in that part is very low by the closed gate and the pollutant of NH_4^+-N can accumulate to reach a high concentration of 15 mg/L which was toxic to all organisms. This has greatly reduced the potentialities of fishery production in Chaohu Lake (Yan Jinsong, 1987).

The high turbidity of the lake is an indirect result of water gate construction. It is known that emersed and submersed plant can fix the underneath sediment and reduce the wave force against the bank. Without the protection of macrophyte, the rate of sediment resuspension and bank erosion is greater than mud deposition in most shore areas. The average depth of the lake is only 3 m, the large resuspension rate causes evenness of the lake bottom, i.e. to erode in the shallow and deposit in the deep part. In the lake, shipping lanes have to be dredged every a few years and mud be transported to surrounding areas, but the wave scour and sediment resuspension just work in an opposite way to fill the lanes and make the dredge a waste of labor and energy.

Chaohu Lake water has a high concentration of nutrient elements with total phosphorus in a range of 0.05–0.20 mg/L and total nitrogen ranging of 0.6–2.6 mg/L. The point sources of pollution discharge water with higher nutrient concentration and bio–available phosphorus ratio higher than non–point sources. The main point source of pollution is Hefei City, the capital of Anhui Province, with a population of 700,000 and some industries. The waste–water is discharged into Nanfei River and enters the lake without treatment. According to chemical analysis, the total phosphorus and nitrogen concentrations in Nanfei River are about four times of the weighted average of other rivers. The calculation shows that the point sources of pollution are the main contributors of the nutrients into the lake. The most important non–point sources are soil erosion and fertilizer loss while the contribution from atmospheric precipitation and forest is not important (Jiang Haigui, 1988). Slight, medium and serious erosion areas occupy 45.5, 14.3 and 0.8% of total catchment area respectively. The soil erosion mainly takes place in dry farming lands, low mountain areas and hillocks with poor vegetation in the upstream catchment of Yuxi River. But the soil and nutrients are partly trapped by the ponds, reserviors and upstream beds. Rice is the main agricultural product in the catchment and fertilizer application per unit area is high. Nitrogen runoff is large from rice fields. For phosphorus load, early rice, which harvests in summer, is not an important contributor but late rice harvesting in autumn greatly contributes to the water system. Besides allochthonous load of nutrients, Chaohu–Yuxi River water has sediment with high nutrient content. The physical factors, such as small depth and strong wind, make the water and sediment mix frequently and the nutrient elements are liberated quickly from mud. This internal source is also important in the process of eutrophication.

NUTRIENT LOAD REDUCTION PLUS ADJUSTABLE WATER LEVEL

The eco-environmental problems form a very complicated diagram (Fig. 4). The environmental quality is still declining and as a result the regional economy will be affected in the future. Human's most urgent task is to turn this vicious cycle into a good succession. Many actions should be taken, among them the priority is to make a scientific set of water management system which takes account of the benefit of all economic-ecologic functions. Several years ago, scientists in Anhui Province raised a proposal of " ecological water level " to keep the level suitable for the requirement of a healthy ecosystem as well as the requirement of boat transportation, agricultural irrigation and city water supply (Anhui Institute for Environmental Protection, 1986). They proposed that in February and March, the water level should be in 7.5 m level, which is higher than 6.2 m level before water gates construction, to sprout submersed and emersed plants and not to impair transportation and irrigation. In April, the water level would be raised, following the growth of macrophyte and in July and August the water level would be kept in 10–11 m level. This is a correct proposal for the ecosystem as well as for the economy. If the macrophyte vegetation can recover in large littoral area, more mud will be deposited in this zone. Lake shore and boat lane will be better protected and the littoral area be further developed. The more important effect is to creat a littoral biotope, the third biotope besides the estuary and the open-water. This biota-biotope system will provide a habitat for different algae, zooplankton and fishes and it will serve as a refuge for some species. The overall purpose is to recover macrophyte waterscape instead of algae bloom.

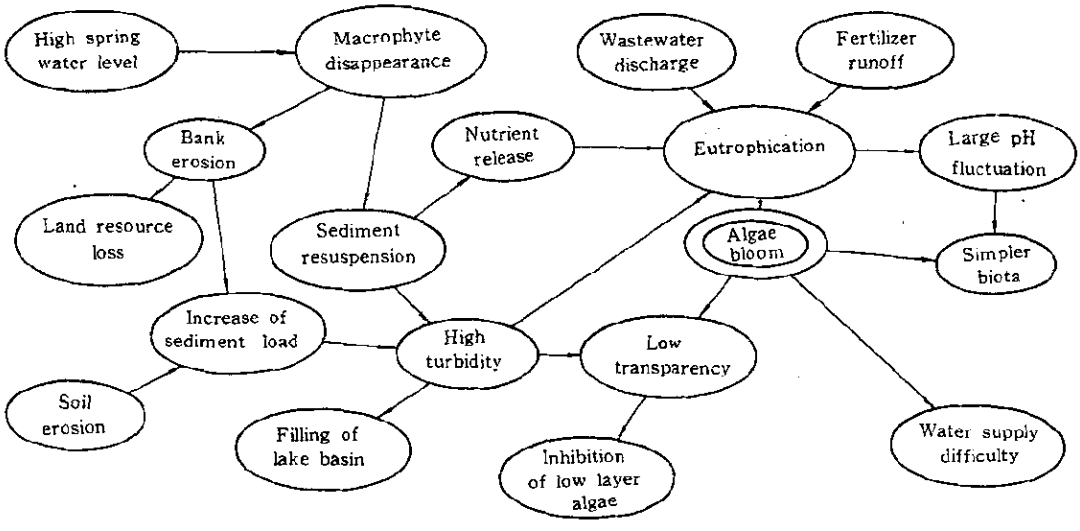

Fig. 4 The interaction of environmental factors in Yuxi River—Chaohu Lake ecosystem.

For the implementation of this proposal, several consequences have to be considered. The area of littoral is one of them. A too small littoral cannot inhabit the *Microcrytis* growth and a too big littoral will probably accelerate the filling of the lake. The other consequences are how to keep the boat lane deep enough, to dispose the dredged material, the security against the possible recovery of perished locust, blood fluke and its host snail, and serious droughts happening every ten years etc. The most possible consequence is that 7.5 m water level in spring can only create a littoral area of 18 km^2, 2.2% of the lake area, its biota-biotope system is probably not big enough to change the biota with *Microcystis* as dominant species. The water level less than 7.5 m should be tested while a further interdisciplinary research should be carried out to prevent bad consequences.

When the spring water level is low enough, the Yangtze River water can flow back into Chaohu Lake through Yuxi River, which will bring millions of fries and migrating organisms. In addition to artificial batching, it is possible to recover a good fish community to convert primary productivity to better aquaculture products.

Eutrophication is the key problem for Chaohu Lake. To reduce the trophic state is a fundamental settle of the problem and the nutrient load has to be cut first at least 20%. Since the point source of pollution is the main cause, waste water treatment of removing nutrient elements can improve the environment quite effectively. There are a number of ways to achieve this, such as to dredge Nanfei River before the flood season and dispose the nutrient-rich sediment out of the water system; to dig up settling oxidization ponds for waste water; to set waste water land treatment system to remove BOD, suspended solids and nutrient elements; to build primary waste water treatment plants. These economical ways can remove phosphorus up to 40% and nitrogen up to 30% and need lower capital expenditure and maintenance cost. In the next stage, it is needed to build large-scaled tertiary treatment plants or chemical phosphorus elimination facilities to remove nutrients to a great extent.

Yuxi River-Chaohu Lake is a complicated system where many ecological problems have accumulated for years. The settlement of any problem is a difficult task of systematic engineering. Now, these problems, especially the water supply, have become more and more the limiting factors of the regional economic development, human being has to do something to improve the environment for the nature as well as for themselves.

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