Rep. Suwa Hydrobiol., 9: 149~153 (1995)
Proceedings of the 7th International Symposium
on River and Lake Environments, 1994, Matsumoto

A "Jellyfish Engineering Experiment" for purifying water quality in large lakes

PU Peimin, HU Weiping and PANG Yong

Nanjing Institute of Geography & Limnology, Academia Sinica; 73 East Beijing Road, Nanjing 210008, China; Fax: +86+25-771-4759; Tel: +86+25-771-39261.

INTRODUCTION

Eutrophication is one of the most serious problems facing in lakes, even large lakes in China at present, in relation with the increasing of population and rapid development of industry and agriculture in lake catchment. Algae blooms more and more frequently appear in many large lakes, such as L. Chaohu, L. Dianchi, L. Taihu, which have surface area of 753, 298, 2338 km^2, mean depth of 2.4, 4.1 and 1.9 m, separately. Areas covered by submerged plant in those large shallow lakes decrease or disappear. The benthos in some parts of L. Dianchi disappeared. The dominant phytoplankton species appeared to be *Microcystis* sp., a cyanobacterium which also causes surface scums. Wind-swept scums accumulated at the shores and clogged the treatment filter systems in the drinking water plants, and led to decrease in drinking water supply, which, for example, led to a large direct economic loss of RMB 130 million in Wuxi, in the end of July, 1990. Moreover, *Microcystis* blooms are known to present toxicological hazards due to production of toxins. To control the eutrophication of large shallow lakes in China is of extreme importance.

CONCEPTIONAL MODEL OF EUTROPHICATION AND ITS CONTROL

To decrease the nutrients in lake water is the essential method of eutrophication control. According to the mass balance equation, the time variation process of the mean concentration of an inorganic nutrient S may be described by the following equation (see Fig 1.):

$$\frac{\partial AHS}{\partial t} = Q_iS_i - Q_oS_o + A(F_s+F_b) - AH(G+C-D) \qquad (1)$$

or

$$\frac{\partial S}{\partial t} = \frac{1}{H}\left[\frac{QiSi-QoSo}{A} + F_s + F_b\right] - (G+C-D) \qquad (2)$$

$$\frac{\partial S}{\partial t} = \frac{S_i}{T}\left(1 - \frac{QoSo}{A_iS_i}\right) + \frac{Fs+Fb}{H} - (G+C-D)\ ,\ T = \frac{AH}{Q_i} \qquad (3)$$

Where A,H,Q are the surface area, mean depth and inflow of the lake; the subscript i and o, the inflow and outflow, separately;T, the resident time of lake water; F_s , F_b, the fluxes of S into water from air-water and water-bottom interfaces, separately; G, C, D, the variation of S caused by growth of biomass, chemical processes, and decomposition, separately.

From above equations, obviously, for large shallow lakes withe long resident time, the most important elements are F_s , F_b and G, C, D; the $Q_i$and Q_o are secondary important. Therefore, to decrease the nutrients load to Lake Taihu is essential, but not sufficient for controlling eutrophication of the lake. For a Netherlands Loosdrecht lakes the external phosphorus load was been decreasing substantially since 1984, but the employed measures were not successful for counteract eutrophication (Van Liere, L., et al, 1992). For shallow lakes the release of phosphorus and other nutrients from lake sediment and the resuspension of detritus and sediments from bottom obviously (Keizer, P., et al, 1992; Wu, J., et al, 1990). These processes are strengthened by storms and wind waves (Pu, P., et al, 1990). The turbidity changes rapidly in shallow lakes. Fisheries management for controlling algal bloom has resulted in a considerable improvement of water transparency in small lakes (Meijer, M.-L, et al, 1989). Experiments on a middle scale lakes, have so far not been successful (Van Donk,E.M.P., et al, 1990; Chen,S., 1990). The dredging measures may be used for improving the transparency in small lakes (Van der Does, J., et al, 1992), and meet a great deal of technical, financial, and even principle difficulties for middle and large shallow lakes, such as in Lakes Taihu, Chaohu and Dianchi. The flushing measures have been tested in Lake Xihu (Hangzhou, China) with an area of 5.6 km^2 and mean depth of 1.6 m. The water quality improved just in a limited inlet region and in a period of days (Wu, J., et al, 1990).

The new approaches for improving water quality in Lake Taihu and similar large lakes should be developed. The fundamental principles and key measures of the approaches are: to increase the capability of self-purification in lake ecosystem; to encourage the benign cycle of substance by means of adjusting and controlling mainly the internal structure and function within the lake; to transform the nutrients into usable biological resources as much as possible; than to take out the resources from lake as much as possible in order to reach a synchronous development of ecological, environmental, economic and social benefits. The conceptional model of eutrophication and its control is shown in Fig 2. In winter-spring seasons when $G<D$ an increase of S is observed in lakes (Fig 3, 4). By increasing G and taking it out from lake as much as possible, we may decrease D and have $\partial S/\partial t<0$ gradually. To restore and develop the submerged macrophyte in some bays is essential. But there are strong wind wave and current, and rapid changes of water level and turbidity in large shallow lakes(Pu, et al, 1990) It is very difficult in restoring the submerged vegetation in wide area of those lakes. But the net primary production of phytoplankton, for example in L. Taihu accounts 6 $g/m^2/d$ in summer (Pu, et al, 1993). It means that about 140 t nitrogen and 14 t phosphorus dissolved in the water body transform into algae resources daily in wide water surface of L. Taihu by using solar energy and dissolved nutrients. The annual net input of TON and TOP account 3105 and 946 t, separately (Sun, et al, 1993), which are equivalent to the absorbed value by algae during 22 and 68 summer days, separately. If we can take off some parts of algae biomass as a usable resources from water body, we may effectively control eutrophication and improve water quality of the lake. The problem is how to concentrate the algal with minimum artificial energy. A Jellyfish Engineering Experiment (JEE) is developed and taking place for concentrating algae by using wind energy/ wind-driven current in NW part of L. Taihu.

A JELLYFISH ENGINEERING EXPERIMENT IN TAIHU LAKE

The JEE is constructed as a filter with floating soft wall made from industrial filter cloth (Fig. 5). The algae concentration in JEE reaches more than 3×10^9 cells/L or 160 mg/L biomass, which can be taken off by using a pump easily and used as food for animal and fertilizer for agriculture at the present (Zhou, et al, 1988). We may construct some JEE there, where have big appearance possibility of algal bloom along the lake coastal zones, including intake areas of drinking water supply plants, and "catch the rabbits under the trees". Therefore we can take off as much as possible nutrients from large lakes in form of usable resources of algae, purifying water quality, controlling eutrophication of large lakes more realizably and efficiently.

REFERENCES

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

J ф rgensen, S.E., 1986: Fundamentals of Ecoligical Modelling,ElsevierAmsterdam Oxford-New York-Tokyo, pp. 389.

Keizer, P. et al, 1992: Phosphorus in the sediment of the Loosdrecht Lakes and its implications for lake restoration perspectives, *Hydrobiologia*,233:39-50.

Maijer, M.-L., et al, 1989: Restoration by biomanipulation of Lake Bleiswijkse Zoom: firs results, *Hydrobiol. Bull.* 23:49-57.

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

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. 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 Conserv. and Managem. of Lakes, Italy: 480-483.

Sun, S. and Y. Wang, Ed.,1993: Taihu Lake, Oceanogr. Press: 250-261.Van der Does, J., et al, 1992: Lake restoration with and without dredging of phosphorus enriched upper sediment layers, *Hydrobiologia* 233: 197-210.

Van Donk, E.M.P., et al, 1990: First attempt to apply whole-lake food-web manipulation on a large scale lake in The Netherlands, *Hydrobiologia* 200/201: 291-301.

Van Liere, L., et al, 1992: Working group water quality research Loosdrecht Lakes: its history, structure, research programme, and some results, *Hydrobiologia*, 233: 1-9.

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: 469-500.

Yan, J., 1986: The main principles and type of ecological engineering for the conversion of waste water into resources, *Rural Eco-Environment*, 8:40-44.

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 Sinica*, 19: 125-132.

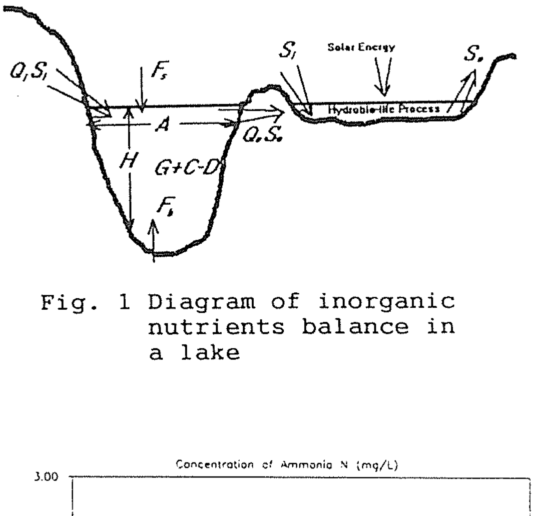

Fig. 1 Diagram of inorganic nutrients balance in a lake

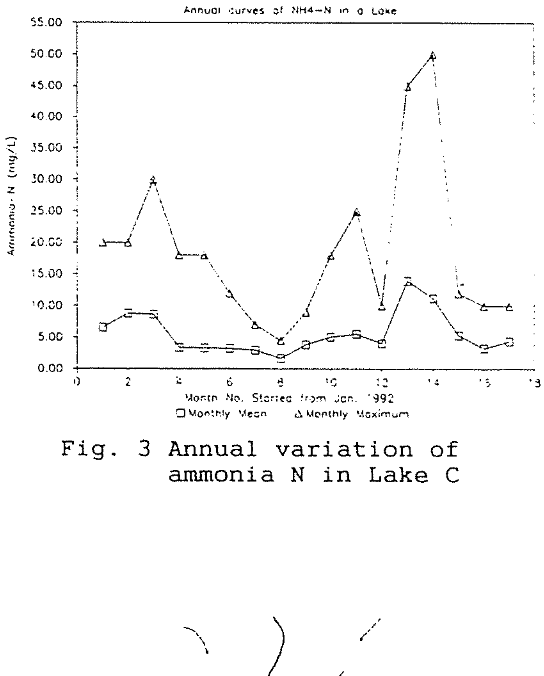

Fig. 3 Annual variation of ammonia N in Lake C

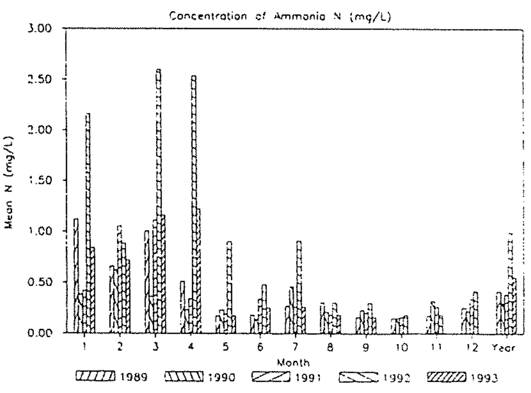

Fig. 4 Annual variation of ammonia N in Lake T

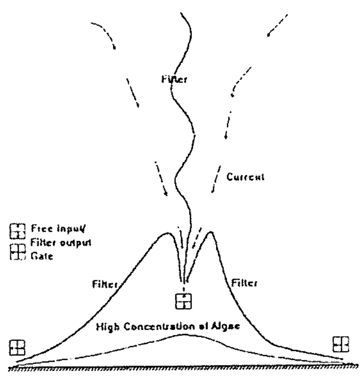

Fig. 5 Diagram of the 'Jellyfish Engineering Experiment' (JEE)

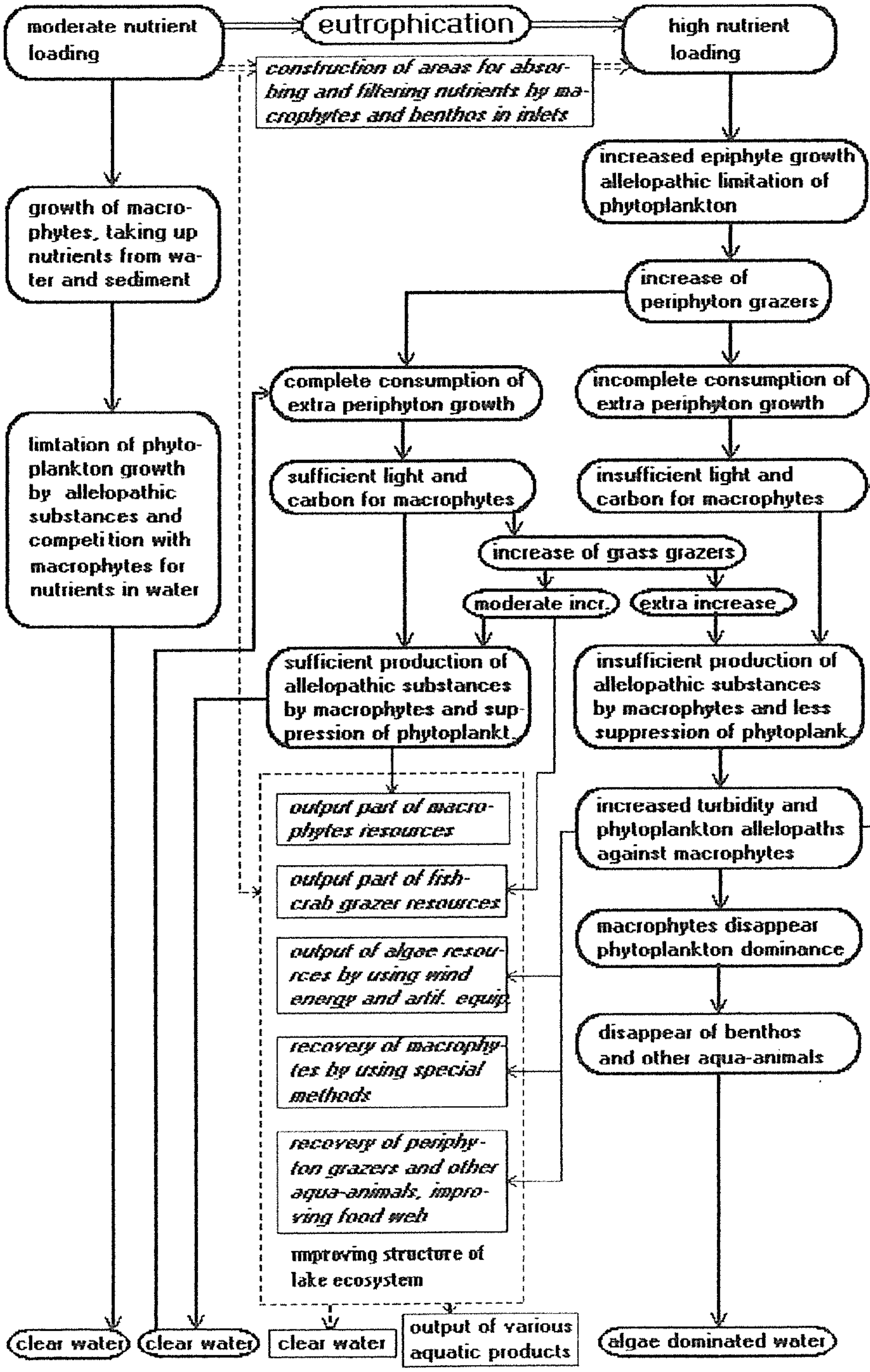

Fig. 2 Diagram of the 'Jellyfish Engineering Experiment'