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CORRELATION BETWEEN WATER QUALITY AND Chl.a OF PHYTOPLANKTON AND THE COUNTERMEASURES FOR INHIBITING ALGAL GROWTH IN WEST LAKE, HANGZHOU

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Abstract

On the basis of the analysis of chlorophyll-a and physicochemical factors in the water of West Lake, the results show that algal growth in Lake Beili, Lake Yue, Lake Xili and Lake Wai is affected mainly by water temperature, and is not limited by the high concentrations of N and P in the water. The water quality in L.Xiaonan is better than that in other lake areas, because it lies at the diversion entrance and is directly influenced by drawing water from Qiantang River. Studies on biological control experiments suggested that a reasonable and coordinated ecological system would be more beneficial to the water quality than the other countermeasures.

Key words: Algae, Chlorophyll-a, West Lake, Countermeasure for eutrophication

Introduction

Chlorophyll is one of the important components of algae. Though different algae have different types of chlorophyll, all algae contain chlorophyll-a. The amount of chlorophyll-a in water is closely related to the species and quantity of algae present. Chlorophyll-a content is therefor one way to determine the environmental quality of the water body, that is, the eutrophic level can be determined by monitoring the chlorophyll-a content in the water body. This has indeed been an increasingly important method of eutrophic evaluation in recent years.

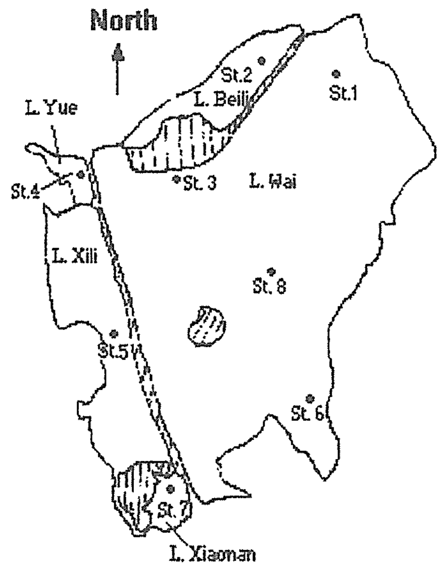
West Lake, a famous touring lake in China, is situated in the west of Hangzhou and is surrounded by hills. The total area of West Lake is 5.66 km^2, which has been divided into five areas by the Su and Bai Causeways. These areas are L. Wai (the major section), L.Beili, L.Yue, L.Xili and L.Xiaonan, and they are linked by channels under the bridges. The water of West Lake comes from three streams (Jinsha Stream, Longhong Stream, Changqiao Stream) and the drawing water comes from Qiantang River. Consequently, the water in West Lake flows from west to east, and finally into the Younger's Palace Pool, which can also control the amount of water in the lake. Due to pollution caused by industrial wastewater, farming effluents, urban sewage and the rapid development of tourism, West Lake has become eutrophicated. Controlling management processes, including pollutants damming, dredging and drawing water have been employed in recent years, so the water quality has improved to some degree, but serious problems still remain, such as an excessive algal growth in summer and autumn. Thus more efficient control measures need to be taken in the future. This paper studies the relationship between chlorophyll-a and several physicochemical factors, as a prelude to exploring more efficient biological methods to inhibit the growth of algae.

Materials and Methods

Sample points were established in Lake Wai, L.Xili, L.Beili, L.Yue and L. Xiaonan. Other sampling points were established at Younger's Palace, Zhongshan Park and Changqiao. The sampling tool used (Type 8001) was produced by the Aquatic Institute of Wuhan. Fixing and analyses of samples were performed on the same day they were taken. The water quality was analysed once a month, as was analysis of aquatic creatures and physicochemical indexes of water quality.

100 ml of sampling water was fixed with Lugol's solution and shaken well to ensure an even distribution. 0.1 ml of the fixed sample was then placed on a slide, and algae cells counted microscopically using a vision field of 50. This process was duolicated for each sample.

Chlorophyll-a was determined according to the method of APHA (1976) 1002G.1. 200ml of sampling water was filtered through acetate fibre filter paper (aperture 0.45 μ). The filter paper was then ground in acetone to extract chlorophyll-a. The sample was centrifuged at a rate of 3500rpm for 20 minutes. The optimum density (OD) of the supernatant was determined spectrophotometrically at 630nm, 645nm and 663nm, and then calibrated to the OD value at 750nm. The chlorophyll content was then determined according to the formula of 1002G.3.



1–Younger'spalace 2–L.Beili 3–Zhongshan Park 4–L.Yue 5–L.Xili 6—Changqiao 7–Center of L.Wai 8–L.Xiaonan

Fig.1 Sampling points in West Lake

Six small experimental ponds were set up in lake Yue, each occupying 5 x 6 m^2. Submerged plants and floating plants were planted in one pond each. Two ponds were cultured with spiral shells and freshwater mussels, respectively. One pond was left undisturbed, as a control for the water in Lake Yue.

Results and Discussion

According to results determined for each month in 1995, the chlorophyll-a content was varied for the different lake areas. Lake Beili recorded the highest average annual chlorophyll-a content (110 μg/L), followed by Lake Yue (83.7 μg/L) in L.Yue, Lake Wai (82.0 μg/L), Lake Xili (78.3 μg/L), and finally Lake .Xiaonan with the lowest average value (20.6 μg/L).

The monthly chlorophyll-a contents found in each lake area in 1995 are shown in Figure 2. From this figure it is clear that seasonal variations in the chlorophyll-a content had occurred. That is, two chlorophyll-a peaks were observed, one in April or May and the other in August for each lake. The highest chlorophyll-a content was found in L.Beili in August (281 μg/L). For L. Xiaonan, the peaks in April and August were too small to be considered significant. Therefore, the chlorophyll-a content in this lake was essentially constant throughout the year.

Table 1. The annual average values of chlorophyll-a (ug/L)

Station	L.Beili	L.Yue	L.Wai	L.Xili	L.Xiaonan
Chl.a content	110.1	83.7	82.0	78.3	20.6

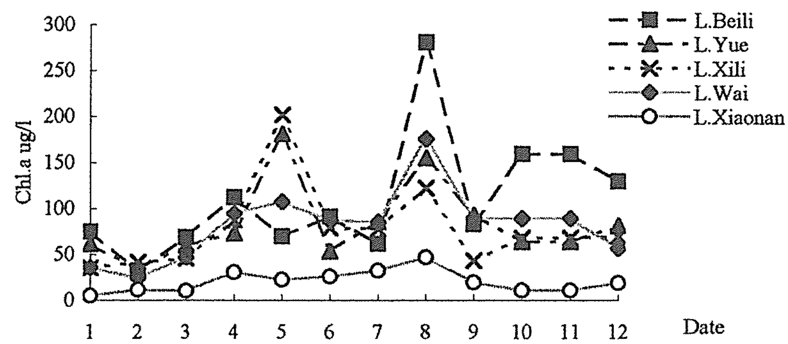


Figure 2. The seasonal variations of chlorophyll-a in each lake of West Lake during 1995

Algal growth is closely related to surrounding environmental conditions. Because it is restricted by light, water temperature, concentration of nitrogen and phosphorus, and many other factors. As chlorophyll-a is an important component of algae, its concentrations in the water body reflect the changing kinds, along with the changing quality of the algae. The chlorophyll-a content is therefore also a measure of the quality of the water environment.

Table 2. The average annual values for TP and TN (mg/L) in West Lake in 1995

Station	L.Beili	L.Yue	L.Wai	L.Xili	L.Xiaonan
TP	0.132	0.152	0.096	0.1042	0.088
TN	2.062	2.989	2.372	2.626	2.894

Figure 3 clearly shows that the seasonal variations in the chlorophyll-a content of L.Beili, L.Yue, L.Wai and L. Xili are directly related to the water temperature (Tw). That is, the chlorophyll-a content peaked at times of high water temperature. During winter (Jan./Feb.), the low temperature is not conducive to algal growth, so the chlorophyll-a content is at its lowest during this period. As the temperature began to rise in spring (April/May), algal growth was encouraged, resulting in a peak in chlorophyll-a content. A further increase in temperature in summer-early autumn (June/Aug.), resulted in even more algal growth and thus a greater peak in chlorophyll-a content. In Sept., a declining temperature due to the approach of winter again reduced the algal growth and corresponding chlorophyll-a content.

The measurement on the concentration of nitrogen and phosphorus in each experiment site in West Lake in 12 months showed that the total concentrations of them were rather high. The total concentration of phosphorus was between 11.36 to 4.43 mg/L. The annual average concentration of nitrogen and

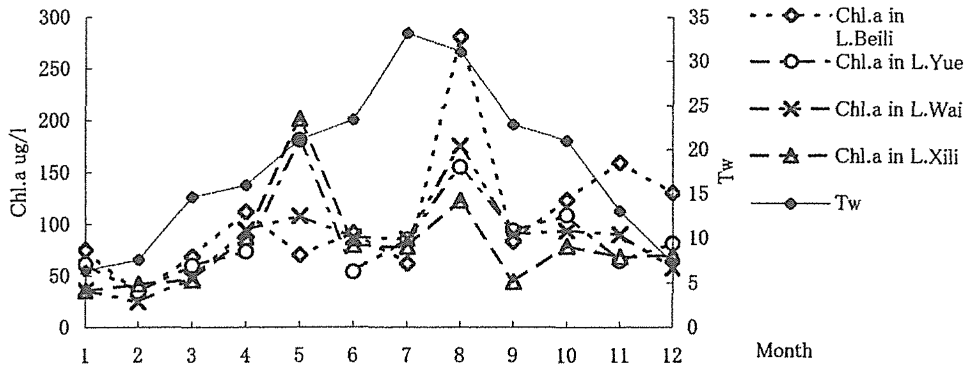


Figure 3. The relationship between chlorophyll-a content and water temperature (Tw) in West Lake in 1995

phosphorus in each site did not have much difference. Compared with that of Table 2, it could be found out that the changes in the concentration of nitrogen and phosphorus did not have relation with those in the concentration of chlorophyll-a.

Because there were plenty of nutrition in nitrogen and phosphorus in West Lake, nitrogen and phosphorus did not act as restrictive factors. It could be inferred that the difference in the concentration of chl.a among the five experiment sites was likely resulted from the influence made by the introduction of the water from Qiantang River and the mountain streams.

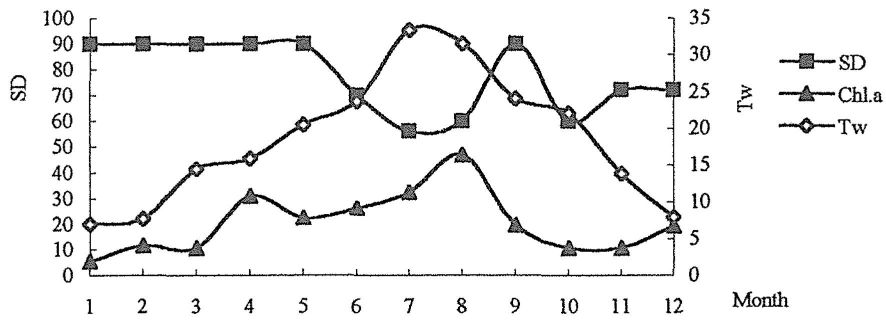


Figure 4. Monthly variations in chlorophyll-a content, Tw and SD in L.Xiaonan in 1995

In L.Xiaonan, which is located at the import of drawing water, replacement of water takes place frequently. This would explain why the chlorophyll-a levels seen in Figure 2 for this lake remained consistently low throughout the year. The monthly transparency (SD) for this lake during 1995 is shown in Figure 4. The chlorophyll-a and water temperature (Tw) has been included in this figure to simplify comparisons. The inverse relationship between SD and chlorophyll-a (and also Tw) is clearly seen in this figure. The SD of this lake remained quite high throughout most of the year, dipping relatively slight in July to August as a result of the small increase in chlorophyll-a, or more precisely algal growth, during this time.

Lake Beili, the other hand, is located far away from the import of drawing water, and has only a limited exchange of water with Lake Wai. Despite the establishment of dredge channel engineering (which has resulted in a slight improvement), the water quality in this lake remains quite poor. This explains high levels of chlorophyll-a content (Table 1 and Figure 2), or algal growth, found in this lake. L.Yue also recorded high chlorophyll-a levels. Althogh it is largely influenced by an adjoining mountain stream, it is still often heavily polluted, with a red tide often visible. Its water quality is therefore somewhat unstable.

Nutritional salts that are necessary for algal growth are plentiful in every region of West Lake. As temperature and other environmental factors become suitable for algal growth and development, the algae reproduc in copious amounts, resulting in a decline in transparecy (SD) and water quality, along with a negative impact to the scenery of the lake. Management processes, including the introduction of water from Qiantang River and dredging, have been introduced in an effort to control the problem of over-nutrition. Although the introduction of river water has managed to dilute the concentration of algae in the lake, the algae still reproduce rapidly under suitable temperature conditions. This form of control is also limited to the quality of the water (for example SD, N and P levels) in the river. Dredging was introduced for the purpose of removing excess nutritional salts from the lake. This was unsuccessful, however, as salts were actually dissolved into the lake water from sediment during the dredging process. Therefore, more effective means of controlling the algal growth are needed. In this section, the results of trials involving several biological control methods are presented.

The trials involved the establishment of several ponds in L.Yue in 1994, four of which contained a form of biological control (including planting of floating or sumerged plants, and culturing of spiral shells or freshwater mussels), and two controls. The results of chlorophyll-a levels measured over time in each pond are shpown in Figure 5.

algae (i.e. chlorophyll-a content), particularly in the peak period (August). The effectiveness of each co
From Figure 5,it is clear that each method of biological control successfully reduced the growth of ntrol method followed the order: submerged plants (55.1% reducction in chlorophyll-a in the peak season) > spiral shells (53.4% reduction) > freshwater mussels (45.9% reduction) > floating plants (37.3% reduction).

It should also be noted that a preliminary outdoor experiments with culturing of spiral shells in a pond visibly resulted in a water clearing affect, and increased the SD rapidly and efficiently. When this cultivation was carried out in conjunction with submerged plants, the clearing effect was observed to be more long term and sustainable. It would therefore be beneficial to conduct further field trials of such biological controls, particuarly in determining possible synergistic effects of two or more concurrent methods

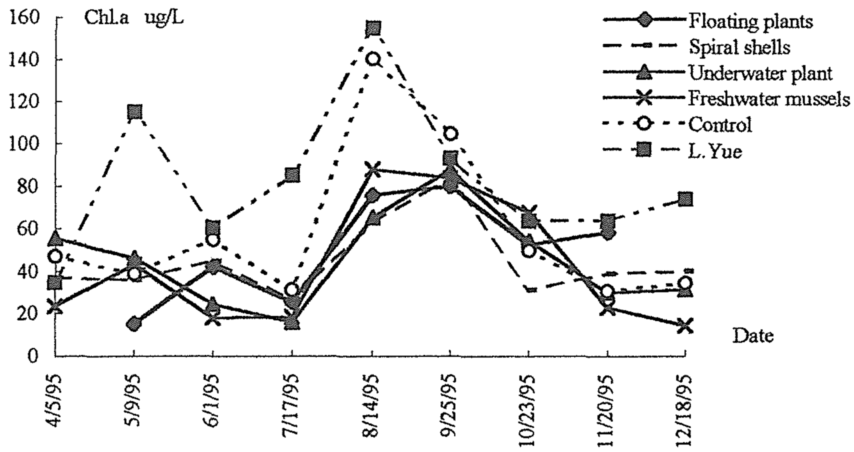


Figure 5. The resultsof the experiment site in L.Yue in 1994

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