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COMPARISON OF CHLOROPHYLL A AND THE ALGAL GROWTH POTENTIAL IN THE WEST LAKE

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Abstract
The present work studied environmental factors, such as temperature, nitrogen, phosphorus, chlorophyll a and transparency of the West Lake. Algal growth potential test (AGP) was performed to determine the influence of the environment elements on the potential of algal growth, and to explain what conditions were necessary for algal reproduction.

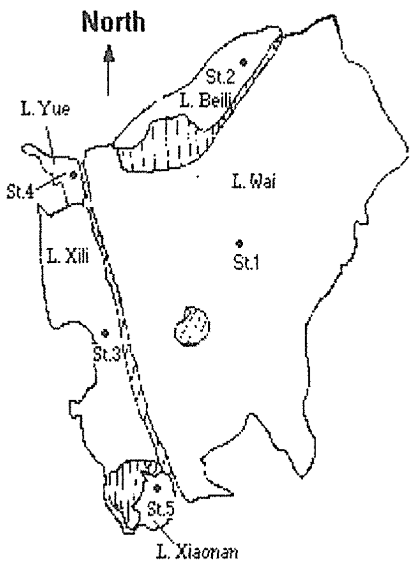
Key words: AGP, *Scenedesmus quadricauda*, Algal density

Introduction

The West Lake, a famous touring lake in China, is situated close to the westside of Hangzhou city, with the other three sides of the lake being surrounded by hills. The area of the lake is 5.66 km^2, and it is divided into five areas by the Su and Bai Causeways. These areas include Lake Wai (the main area), Lake Beili, Lake Yue, Lake Xili and Lake Xiaonan. Because of the development of the urban surrounds and the imperfection of pollutants damming, the West Lake has undergone high eutrophication. Through measuring the environmental elements, and analyzing the mutual relationships of physicochemical properties of the lake water, the changes in chlorophyll-a and the AGP will be analyzed.

Materials and methods

According to the distribution of the five lake areas, we established five sampling points in the centers of each lake (Figure 1). The water sampling tool used was produced by the Aquatic Institute of L.Wai. The environmental elements, such as temperature, transparency, nitrogen, phosphorus and chlorophyll-a were measured and analysed on the same day of every month.



Chlorophyll-a was detected using the method of APHA (1976). 200ml of sampling water was filtered through acetate fibre filter paper (pore size: 0.45μ), then extracted with 90 acetone and centrifuged at a rate of 3500 rpm for 10 minutes. The optical densities (OD) of supernatant of 630, 645, 663 and 750nm were measured and the amount of chlorophyll-a was calculated based on the formula of 1002G.1.
Normal culture salt fluid was compounded to seven bottles of stored spare culture fluid containing relevant trace elements. 900ml of distilled water was added to 1ml of stored spare fluid and 1ml of trace culture fluid, and then adjusted to 1000ml by addition of further distilled water.
Culture media were constructed using two parts spare culture fluid to three parts agar. The plates were cooled flat, and carefully checked to ensure that no contaminating bacteria were present. Fresh water samples collected were evenly distributed on the plates and cultured in a diurnal growth chamber. After the growth of algae each sample was examined by microscopy after. This enabled us to select healthy algal cells from regions of high growth. The algae were precultured if there was no evidence of mixed algae or bacterium. Otherwise cultures of single algae were achieved through repeated culturing stages.
Eight 250 ml cone-bottles containing 100ml of AGP culture fluid were prepared.
One drop of the separated algae was placed in the AGP culture fluid. The culturing temperature was 24-25℃, the illumination intensity was 2500-2900L, and the culture was static culture in the diurnal growth chamber. After about five days, half of the culture fluid was extracted and fresh culture medium was added. The algae was maintained in a suspended state by occasional shaking.
Prior to inoculation, the density of algae in the precultured fluid was determined. The test was then made into two groups.

First group: The water samples of five sampling points in Xiaonan Lake (east, south, west, north and center of the lake) were filtrated for twice using 0.45μ filter paper to discard impurities from the lake water. 40ml of each sample was placed in 150ml cone bottles. The species of algae was *Scenedesmus quadricauda* and the AGP culture fluid was contrasted.

Second group: The water samples were obtained at each sampling point from Lake Wai, L. Bili , L. Yue and L. Xili. Impurities were filtrated out by the same method as above. Each sampling was duplicated, and added to AGP culture medium in cone bottles as above. The species of algae was also *Scenedesmus quadricauda*.

The precultured algae solutions were evenly mixed, and 10 ml of fluid placed in each culture bottle. The density of algae fluid (D) in each bottle was determined. The culturing conditions of the inoculated algae were identical to the preculturing conditions described above. From this point, the algae were counted daily and the change in density of algae in each culture bottle was determined.

The culture fluid was evenly mixed. 0.1ml of culture fluid from each bottle was then placed on a slide, The field of vision of the microscope was adjusted to encompass a count of 50 algal cells. From the area of the resultant field of vision and the depth of the water sample, the density of algae in each culture bottle could then be determined (50SIL)(/L).

Results and discussion

The following environmental factors were detected and analysed from May 1995 to April 1996: Tw, DP, NH_4 -N, NO_2 -N, NO_3 -N. The results are shown in Figure 1-1.

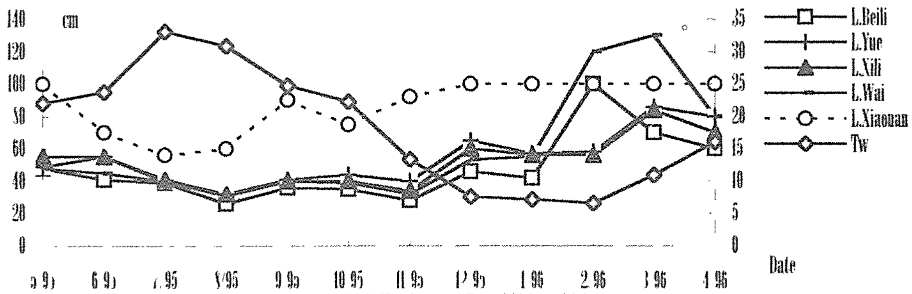


fig.1-1 The change of Tw and SD in each lake area

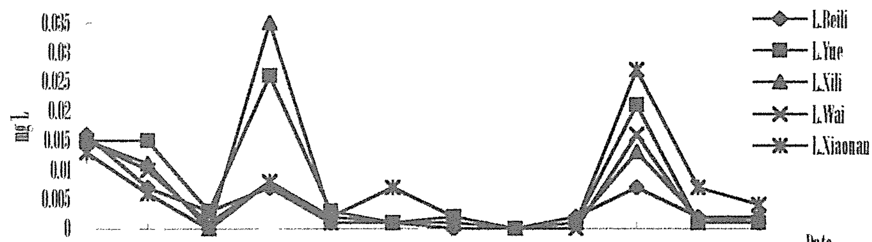


fig.1-2 The change of orthoposhate in each lake area

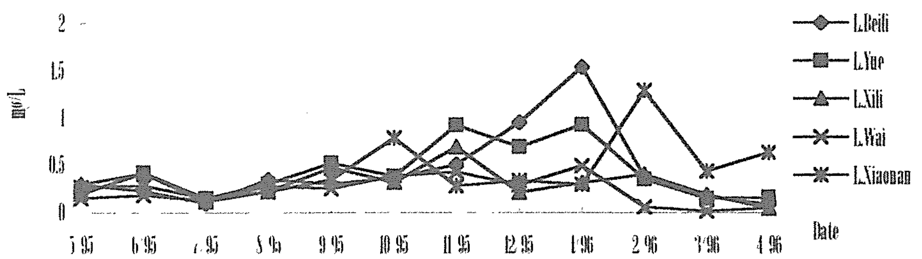


fig.1-3 The change of NH4-N in each lake area

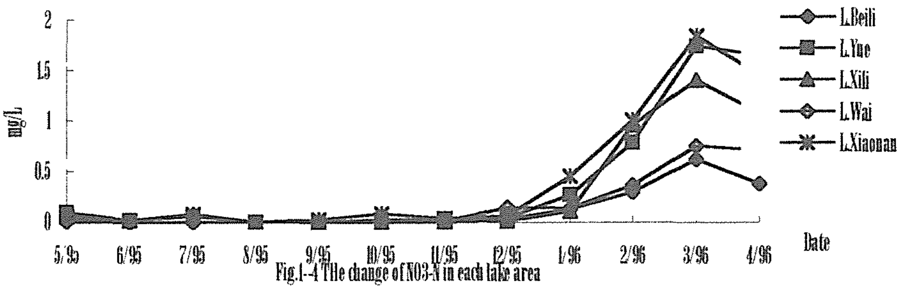


Fig.1-4 The change of NO3-N in each lake area

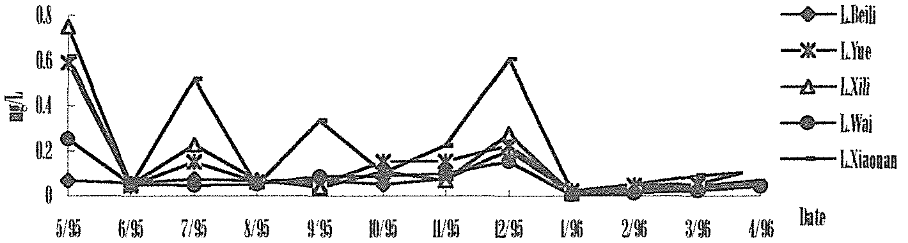


Fig.1-5 The change of NO2-N in each lake area

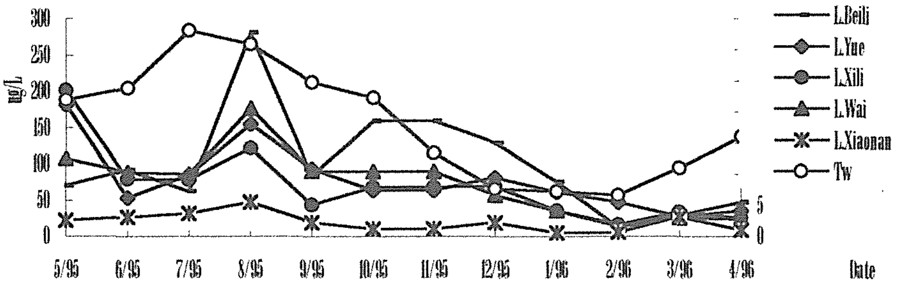


Fig.2 The change of chl.a and Tw in each lake area

In Figure 1-1, the Tw of each lake area revealed a synchronous annual variation. Water Tw had a positive relationship with the atmospheric Tw, so the Tw of Lake Wai was used to reflect all the lake areas. The highest temperature of lake water occurred in July and August, with the temperature of Lake Yue being as high as 33.5℃. The same figure shows that SD had a negative relationship with Tw. L. Xiaonan had the greatest fluctuation, perhaps as it was affected by drawing water. The value of SD for L. Xiaonan was the highest of all the lake areas. The SD for January to March was about 100-130cm, with Lake Wai being as high as 130cm. The SD for June and November was only 25-40cm, with L.Beili being as low as 26cm. The order of the average monthly of SD for all the lake areas was: L.Beili< L.Xili< L.Yue< L.Wai < L.Xiaonan.

Figure 1-2 shows two dominant peaks for DP, one in July to September, peaking in August and the other in January to March, peaking in February. DP varied greatly for L.Xiaonan, L.Yue and L.Xili ranging between zero and 0.035mg/L. In Figure 1-3 to 1-5, NH_4-N, NO_2-N and NO_3-N had similar variation trends, except their peaks appeared at different times.

Comparing the physicochemical factors shown in each of the above graphs, we can see that the water quality of L.Xiaonan and L.Wai were generally better than that for L.Yue, L.Beili and L.Xili.

Figure 2 shows the direct relationship between Tw and chlorophyll-a. Generally, chlorophyll-a had a positive relationship with Tw and a negative relationship with SD. The highest annual value of chlorophyll-a occurred in L.Beili and L.Yue, being 99.8 μg/L in L.Beili. Two peaks also appear in the chlorophyll-a curve; one in May and the other in August. Although the nutrient concentrations were high in L.Xiaonan, the value of chlolophyll-a was the lowest, being only 19.76 μg/L. The order of chlorophyll-a was : L.Beili > L.Yue > L.Wai > L.Xili > L.Xiaonan.

The AGP curves at each sampling point in L.Xiaonan and each lake area are shown in Figure 3-1 and 3-2, respectively. These curves showed the algae to have undergone an initial steady growth, followed by a lag period. This was due to the consumption of nutrients causing a reduction: in DO and space, thus inhibiting the growth of algae. AGP was different in each lake area due to their different nutrient salt contents. The algae growth of the AGP culture was greatest in both sample groups. This was due to the control having higher concentrations of DP and N.

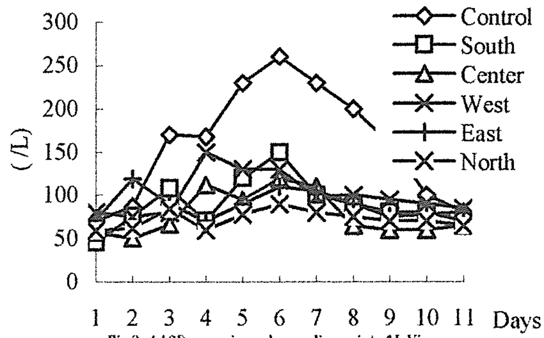


Fig.3-1 AGP curve in each sampling point of L.Xiaonan

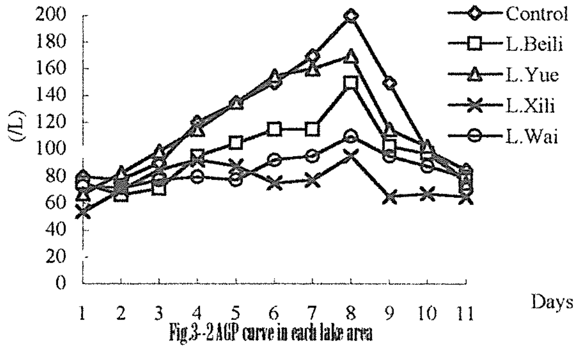


Fig.3-2 AGP curve in each lake area

Based on the highest growth of the control (i.e. Maximum density minus the initial density), the relative percentage of maximum growth in each lake area was calculated. These percentages are shown in the following Table 1 for each lake area.

Table 1. The relative percentage of maximum growth in each lake area

Lake areas	L. Beili	L. Yue	L. Xili	L. Wai.	L. Xiaonan
(%)	62.5	85.8	34.15	30.8	32.6

According to the results of this table, the maximum percent growth occurred in L.Yue. therefore, by calibrating L.Yue to 100% maximum growth, it follows that the maximum percentage growth for L.Yue (100%) > L. Beili (72.8%) > L.Xili(39.8%) > L.Xiaonan(38%)> L.Wai (35.9%). Following similar calculations on the percent AGP in each sampling point of L.Xiaonan, we find the % maximum growth for each sampling point in this lake to be South> West> Center> East> North. These results are shown graphically in Figure 4-1 and 4-2.

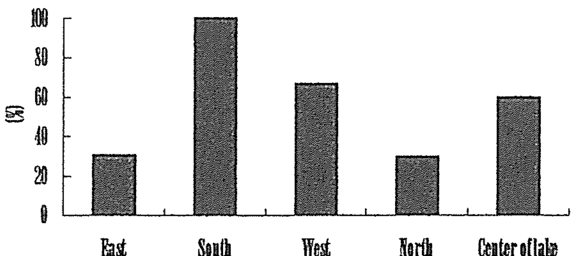


Fig.4-2 The comparison of AGP in each sampling point of L.Xiaonan

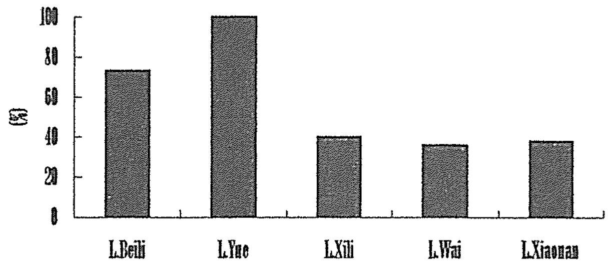


Fig.4-1 AGP in each lake area compared with L.Yue

The results obtained for the AGP tests conform to the results for SD, chlorophyll-a and the other indexes. From this we can see that the main influential factors on algal growth were nitrogen and phosphorus. The seriously polluted lake areas were found to be L.Yue and L.Beili, while the water quality in L.Wai and L.Xiaonan was good.

Conclusions

The laws of annual variation of Tw, SD, chlorophyll-a and DP were adhered to obvious. The variations in NH_4-N, NO_2-N and NO_3-N were determined by several other factors. SD had a negative relationship with

Tw, and a positive relation with chlorophyll-a. SD peaked from Jan. to March, reaches its peak, due to mainly the low Tw (<10℃) at that time. At this low temperature, some algae die, while others can't reproduce. Therefore, Tw was the limiting factor for SD during January to March in West Lake.

L.Xiaonan had the best water quality out of all the lake areas. It had a higher nutrient concentration, lower chlorophyll-a, and a good transparency. This was due to L.Xiaonan having close contact with drawing water. Based on the data presented, the values of nitrogen and phosphorus in the adjasent Qiantang River have increased. The drawing water not only brings more nutrients into L.Xiaonan, but also brings in sands, raising the SD of L.Xiaonan. The low amount of algae in Qiantang River also dilutes the algal density in L.Xiaonan, so the value of chlorophyll-a in the lake is lowered. On the contrary, L.Yue and L.Beili had the worst water quality as they lie of the dead space of drawing water.

The drawing water from Qiantang River played some role in restoring the eutrophication of West Lake, but the rapid development of the tourism, the dense surrounding population, the waste discharges and the increasing amounts of nitrogen and phosphorus in the Qiantang River must have a greater focus when considering countermeasures against the eutrophication in West Lake.

The rich amount of nitrogen and phosphorus in West Lake is a direct influence on algal growth. The higher AGP of L.Yue was directly due to a higher nutrient concentration in this lake (e.g. higher DP, NH_4 -N, NO_2-N, NO_3 –N). Its small area, rich pollution sources, dead space of drawing water and long residence time combined with a heavy tourist load are probably also responsible for its high AGP.

L.Xiaonan and L.Wai were shown to be better: with light pollution, good water quality, high SD and low AGP. According to the physicochemical properties of West Lake studied in this paper, we found that L.Xiaonan had high nutrient concentrations in, while its chlorophyll-a content was the lowest. Of several points analysed in this lake, the AGP in its western point was not high, despite it having a rich nutrient concentration. Its AGP was lower than that of L.Yue. When the concentrations of nitrogen and phosphorus are high enough to meet the needs of algal growth, they are no longer limiting factors. Therefore there must be other determining factors which influence the growth of algae. Further research will be necessary in order to these factors determine

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