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Study of primary production of phytoplankton and the environmental factors in Chaohu Lake water

Du Xiuying and Li Yuxian

Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China

Abstract— Primary productivity was measured by the oxygen method. When there was no algal bloom, the lake water appeared clean and there was no difference between the upper and lower part of the lake water. The dissolved oxygen (DO) approached saturate around 7.0 mg/L. The average productivity rate was 0.2–0.6 g O_2/m³d, and slightly larger than respiration rate. During the period of heavy algal bloom in late September 1987, the productivity even reached 1.6g O_2/m³ d. The average net productivity was 0.22g O_2/m³ d, equivalent to 0.07 g C/m³ d. Meanwhile, the respiration rate was also high and pH reached 9–10. The variation of water temperature, pH, and DO, at various depths of the lake, are not large due to its shallowness and turbulent mixing.

Keywords: primary production; phytoplankton; respiration.

INTRODUCTION

Primary production is the base of the bioproduction and the first node of food chains. It is also a basic measurement of the potential fishery of a water body.

Productivity of phytoplankton is measured as gross photosynthesis, (i.e. the total intake of energy or carbon) and as an approximation of net productivity (i.e. the effective production of new cell material after respiration requirements). The productivity is generally measured by enclosing a sample in a clear glass bottle and measuring either the release of oxygen or the uptake of carbon dioxide. They express different aspects of photosynthesis, and are known as the oxygen method and ^{14}C uptake method, respectively (Gaarder, 1927; Steeman, 1952).

In the 1960s an international effort was made to collect data on productivity from a wide variety of lakes, under the auspices of the international biological programme. A synthesis of results was made by Brylinski and Mann (Brylinski, 1973), in which most data were on phytoplankton production from natural lakes.

In China, Wang Ji and Shen Guohua (Wang, 1981) studied the primary production of the phytoplankton of Lake Donghu and its correlation with various ecological factors (light transparency, water temperature, chlorophyll-a content). In recent years the pollution of Chaohu Lake has been investigated by some researcher and we studied the primary production of Chaohu Lake in the project of CERP.

RESEARCH METHOD

The tests were carried out in May and September of 1987－1989 at Zhongmiao experimental station. In our studies the oxygen method was used to estimate the productivity of the phytoplankton, since Chaohu Lake is relatively eutrophic and the algal bloom occurred frequently. Usually, the primary productivity is so high that the respiration by bacteria can be ignored. So it is easy to estimate both gross and net productivity of phytoplankton by this method.

Samples were taken at 0.5, 1.5 and 2.5 m below the water surface. Duplicate samples for both light and dark bottles were put at the same depth as the original sampling initially DO, pH and water temperature were measured. All resuspended bottles were withdrawn after 24 h of incubation. The dissolved oxygen and pH were tested: DO was measured by the membrane electrode and chemical titration method. The results of the measurement were very similar. It is supposed that in the light bottle, increased oxygen is the difference between the production of phytoplankton and the consumption of respiration by the phytoplankton, the microorganisms and the zooplankton present. In the dark bottle no oxygen is produced, but oxygen is consumed by respiration of these organisms. The respiration of the plankton community is supposed to similar in both dark and light bottles. Total oxygen production, equivalent to gross photosynthesis, is then the difference in oxygen concentration between the bottles at the end of the incubation, gives the gross photosynthesis during the incubation.

$$Pg=(L-I)+(I-D)=L-D,\ \text{g}\ O_2/\text{m}^3\,\text{d}; \tag{1}$$

$$R=I-D,\ \text{g}\ O_2/\text{m}^3\,\text{d}; \tag{2}$$

$$Pn=Pg-R,\ \text{g}\ O_2/\text{m}^3\,\text{d}; \tag{3}$$

where Pg is gross productivity; R is rate of respiration; Pn is net productivity; I represents the oxygen concentration at the start of incubation, mg/L; L is the oxygen concentration in the light bottle at the end of incubation, mg/L; D is the concentration of oxygen in the dark bottle at the end of incubation, mg/L.

The rate of oxygen release, can be converted to the rate of carbon uptake, by calculation from the summary equation of photosynthesis ($6\,CO_2+6\,H_2O=C_6H_{12}O_6+6\,O_2$), in which the production of 1 mg O_2 is equivalent to uptake of 0.37 mg C.

RESULTS AND DISCUSSIONS

Ordinarily, when there was no algal bloom the lake water appeared clean and the gross productivity rate was in the range of 0.2－0.6 g O_2/m^3 d which was slightly larger than respiration rate. Sometimes the respiration rate was equal to or a little larger than the productivity rate (Fig. 1). The net productivity was close to zero or negative at the depth of 1.5 m and 2.5 m.

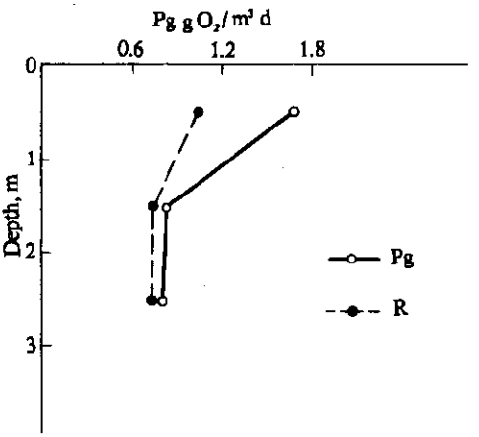

Fig. 1 The vertical distribution of gross productivity and respiration rate in Sept. 1987

During the period of heavy algal bloom the productivity even reached 1.6 g O_2/ m^3 d (Fig. 2). The average net productivity was 0.22 g O_2/m^3d equivalent to 0.07 g C/ m^3d.

Generally, the productivity rate at the upper part of the water (0.5 m under the surface of water) was two times larger than that found at the lower parts.

The experiments of May and September 1988 have shown that the time when respiration rate was larger than photosynthetic productivity were the days of the later bloom period. Per-

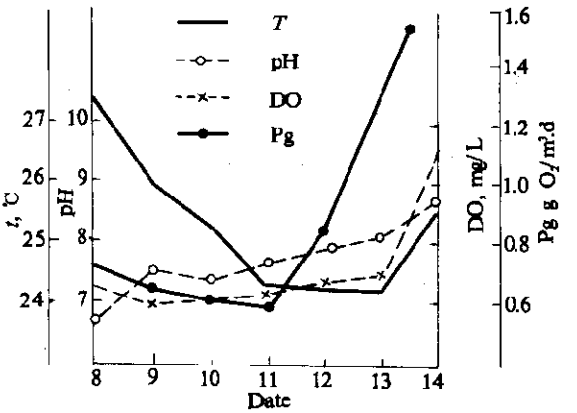

Fig. 2 The variation of the water temperature, pH, DO and gross productivity (*Pg*) at the depth of 0.5 m under the water surface in Sept. 1987

haps the phytoplankton becomes old, and their ability to photosynthesis weakens, while at the same time, respiration becomes stronger.

Although consumed oxygen was more than the amount produced by photosynthesis in the deeper layer, the dissolved oxygen concentration of the whole body of water in the lake did not alter markedly. This is because Chaohu Lake is very shallow and oxygen can be supplemented from the atmosphere by turbulent mixing.

Under normal conditions, the water temperature, pH and DO, show no difference between the upper and lower parts of the water. The DO was close to the value of saturation (7.0–7.2), about 90% of the value of saturation; and pH was 7.5–8.5 (Fig. 3). During the heavy bloom period over saturation of DO has been found, and the pH rose to more than 8.5 even up to 10 (Fig. 2).

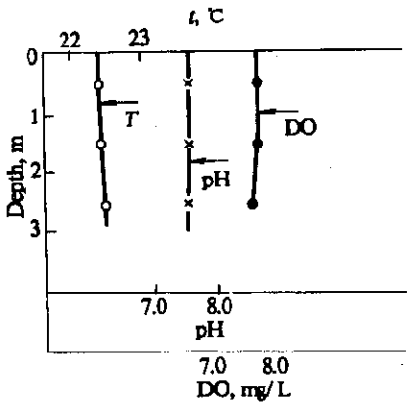

Fig. 3 The distribution of the water temperature, pH and DO at different depth in Sept 1988

Even under normal conditions, the average lake water transparency was found very small. Secchi Disc depth readings were usually short than 20 cm. The Secchi Disc depth is related to the turbidity of the water body, which depends on the algal concentration and suspended matter. Here, Secchi Disc depth reading varied with the concentraiton of silt. Vollenweider (1970) estimated from experience that Secchi Disc readings disappear when irradiance values are between 15% and 20% of the incident radiation. Table 1 shows the light penetration measured for two days at 10 a. m. in Sept. 1988.

Table 1 The light penetration measured as irradiance (lux) at different depth in Chaohu Lake/

Depth, m	Irradiance, lux	
0.0	40000*	48000
0.2	8000	6000
0.5	4500	3200
1.0	750	600
1.5	70	90
2.0	–	–

* Expected value

Irradiance was measured with a water irradiant mater made in China (model SZD-2)

The quantitative survey of algae was carried out in Sept. 1988. Algae were counted by microscope. The total number of algae were counted at 3.4×10^5 per liter when algal bloom developed, after the algal bloom a reading of 0.6×10^5 per liter was obtained. Those amounts are the same in the order of magnitude with that in the early study. The dominant species was *Microcystis*, occupying more than 90% of the algal population.

The relation between productivity and chlorophyll-a content has been shown in Fig. 4.

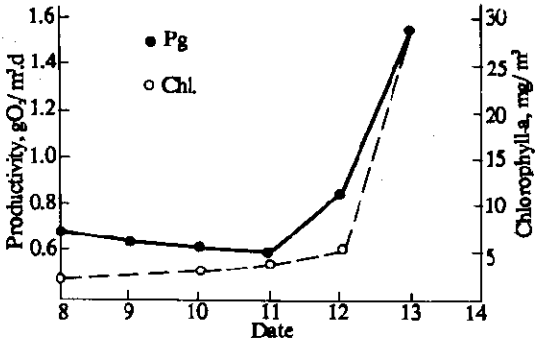

Fig. 4 The relation between productivity and chlorophyll-a content in September 1987

CONCLUSION

The primary productivity in Chaohu Lake was mainly contributed by blue-green algae of *Microcystis* which occupied more than 90% algal biomass in the most period of study.

The average gross productivity rate was 0.2—0.6 and slightly larger than respiration rate at 0.5 m below water surface. The average net productivity was 0.22 g $O_2/m^3\cdot d$, equivalent to 0.77 g $C/m^3\cdot d$. The variation of water temperature, pH and DO at various depths of the lake were small due to its shallowness and turbulent mixing. The productivity, pH and DO had clear relationship with the appearance of algae in the lake water.

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