NOTE

Seasonal Variation of Dominant Phytoplankton, Chlorophyll a and Nutrient Levels in Nearshore Waters of the South Basin of Lake Biwa*

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Abstract

The dominant phytoplankton, chlorophyll a, phosphorus (total and dissolved inorganic) and nitrate plus nitrite nitrogen were surveyed at 7- to 10-day intervals from spring of 1980 to summer of 1981 in nearshore waters of the south basin of Lake Biwa.

From June to November, green algae dominated approximately with the following succession: Closterium, Pediastrum, and Staurastrum. The most dominant phytoplankters from December to May were Fragilaria, Asterionella and Cryptomonas. Moreover, Melosira and Cryptomonas were abundant almost throughout the year. Besides the above-mentioned genera, Anabaena, Uroglena or Mougeotia dominated for short periods of time. Peaks of chlorophyll a concentration appeared in spring with the predominance of Cryptomonas, Uroglena or Closterium and in autumn with the predominance of Staurastrum, Melosira or Fragilaria. Total phosphorus showed a large fluctuation ranging from 20 to 85 µg·l⁻¹ with the annual mean of 47 µg·l⁻¹. Dissolved inorganic phosphorus was rather high (3-40 µg·l⁻¹) from May to October and low (0-5 µg·l⁻¹) from November to April. No clear correlation was found between the concentrations of chlorophyll a and total phosphorus or dissolved inorganic phosphorus. Nitrate plus nitrite nitrogen disappeared frequently in summer, suggesting the nitrogen limitation to phytoplankton growth in this season. In other seasons except for a short period of autumn, these forms of nitrogen were high (100-300 µg·l⁻¹).

1. Introduction

Like many other lakes, Lake Biwa, the largest lake in Japan with an area of 670 km², has undergone progressive eutrophication in recent years. In particular, its small (57 km²) and shallow (mean depth, 3.5 m) south basin receives a large amount of sewage and industrial wastes from surrounding areas, and has resulted in a eutrophic condition.

Although many studies have been carried out on the water quality and biota of Lake Biwa for the past several decades (Mori, 1980), there was almost no report that studied simultaneously the temporal variations of phytoplankton and nutrient levels as surveyed by short intervals such as a few days to one week. In shallow and eutrophic lakes like the south basin of Lake Biwa, especially in nearshore waters, dominant species and standing crop of phytoplankton are suggested to change significantly during a short period under the influence of temporal changes in nutrient supply from inflowing rivers and bottom sediments. The purpose of the present study was to clarify the temporal variations of phytoplankton and important nutrients, i.e. phosphorus and nitrogen, and their relationships.

2. Methods

For the sake of frequent observations, samplings of water were made at the point of the pier at the Otsu Hydrobiological Station, Kyoto University, located on the west coast of the south basin (Fig. 1). Since water depth at this site was shallower than 2 m, lake water became frequently turbid by resuspension of sedimented matter even under gentle wind. Moreover, a small river and several ditches containing a high sewage concentration poured into

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the lake near the sampling site. For these reasons, nutrient levels of lake waters at the sampling site were expected to be higher than those of offshore waters.

Surface waters were collected with a clean bucket at 7- to 10-day intervals. About 200 ml portion of the collected water was immediately fixed with LUGOL solution and allowed to stand for over 48 hrs for sedimentation of plankton. The precipitates were observed with a microscope for the determination of dominant phytoplankters. Another portion of the collected water was filtered through a glass fiber filter (Whatman, GF/C). Residues retained on the filters were used for the determination of chlorophyll a by the method of UNESCO (1969). Dissolved inorganic phosphorus (MURPHY and RILEY, 1962) and nitrate plus nitrite nitrogen (diphenylamine method after SAITO (1962)) were determined by using the filtrates. Total phosphorus was measured by the persulfate oxidation of raw water (MENZEL and CORWIN, 1965).

3. Results and Discussion

The maximum (27°C) and minimum (3°C) surface water temperatures were observed in August 1980 and in early January 1981 in the first year, respectively. However, a higher temperature of about 30°C was recorded at the end of July 1981 in the second year, when this study terminated.

Seasonal succession of some dominant phytoplankters is shown in Fig. 2. Dominant phytoplankters, which appeared almost throughout the year, were the diatom Melosira and the flagellate Cryptomonas. The most predominant phytoplankters from winter to spring were Fragilaria, Asterionella and Cryptomonas. From June to November, green algae dominated approximately with the following succession: Closterium, Pediastrum and Stauroastrum. Besides the above-mentioned genera, Anabaena, Uroglena or Mougeotia dominated for short periods of time.

![Fig. 1. Lake Biwa and the location of Otsu Hydrobiological Station (OHBS) as the study site.](image)

![Fig. 2. Seasonal change of the predominant phytoplankters. The solid circle shows the most predominant phytoplankter at each sampling time. Anab., Urog. and Moug. in the column of “Others” represent Anabaena, Uroglena and Mougeotia, respectively.](image)
Figure 3 shows seasonal change in chlorophyll \( a \) concentration. It was high in late spring and autumn, and low in late summer and winter. The maximum chlorophyll \( a \) concentration (28 \( \mu g \cdot l^{-1} \)) was observed at the beginning of May 1981, when the flagellate Cryptomonas was most predominant. It can be suggested from Fig. 3 that two periods with high phytoplankton standing crop, each having several sharp peaks, appear in the south basin of Lake Biwa, i.e. one in spring and the other in autumn. The appearance of such two periods with high phytoplankton standing crop is interesting, since no thermal stratification develops throughout the year in the south basin because of its shallowness. The annual mean concentration of chlorophyll \( a \) from May 1980 to April 1981 was 9.4 \( \mu g \cdot l^{-1} \). Thus, the level of chlorophyll \( a \) concentration at the study site was intermediate between the levels of mesotrophic and eutrophic lakes. The level of chlorophyll \( a \) in offshore waters of the south basin was almost the same as that in nearshore waters (Tezuka, unpublished).

Mitamura and Saijo (1981) reported a range of 2-6 \( \mu g \cdot l^{-1} \) of chlorophyll \( a \) in offshore waters of the south basin from June 1971 to June 1972. The present level of chlorophyll \( a \) suggests that the south basin of Lake Biwa has been eutrophicated during the last decade.

Seasonal variations of total phosphorus and dissolved inorganic phosphorus are shown in Fig. 4, where it is evident that both forms of phosphorus fluctuate violently. Total phosphorus from May 1980 to April 1981 ranged from 20 to 85 \( \mu g \cdot l^{-1} \) with the annual mean of 47 \( \mu g \cdot l^{-1} \). Dissolved inorganic phosphorus was rather high (3-40 \( \mu g \cdot l^{-1} \)) from May to October and low (0-5 \( \mu g \cdot l^{-1} \)) from November to April. The reason for such a great fluctuation is unknown, but the quality of water flowing from the north basin into the south basin, sewage from the terrestrial area, and the resuspension of bottom mud by wind must have contributed to such fluctuation. By comparing many lakes of different trophic degrees, Schindler (1978) found a clear correlation between the annual mean con-
centration of chlorophyll $a$ and the annual mean concentration of total phosphorus. According to his formula, the chlorophyll $a$ level (9.4 $\mu g\cdot l^{-1}$) at the study site is too low with reference to the total phosphorus level (47 $\mu g\cdot l^{-1}$). In addition, there was no clear correlation between the concentrations of chlorophyll $a$ and total phosphorus or dissolved inorganic phosphorus, as can be easily seen from Figs. 3 and 4.

Nitrate plus nitrite nitrogen was analyzed only from July 1980, and the initial stage of this analysis was done only qualitatively or semi-quantitatively (Fig. 5). In spite of such situation, it is evident that these forms of nitrogen disappeared frequently in summer of 1980, and their concentrations were high in other seasons except for a short period of autumn, when a bloom of Melosira appeared. The predominance of heterocyst-bearing Anabaena in July 1980 (Fig. 2) might have some connection with the shortage of dissolved inorganic nitrogen. A bloom of Anabaena also appeared from August to September 1981 in the south basin with the concomitant shortage of dissolved inorganic nitrogen (Tezuka, unpublished).

As mentioned above, no clear thermal stratification of water develops in the south basin throughout the year. Nevertheless, high standing crop of phytoplankton appeared in spring and autumn as in many dimictic lakes. Low phytoplankton standing crop in winter may be attributed to low water temperature and low light intensity, whereas low phytoplankton standing crop in summer is considered to be due to the shortage of dissolved inorganic nitrogen in the lake water.

The south basin of Lake Biwa is nourished mainly by a large amount of the surface water of the north basin. The north basin (mean depth, 45.5 m) is a typical monomictic lake (i.e., one circulation period appears only in winter). Hence, detailed chemical analyses of water in the north basin will give clues to clarify the reason
for the appearance of high phytoplankton standing crop in spring and autumn in the south basin.

摘 要

琵琶湖南岸の西岸に位置する京大・大津臨湖実験所の桟橋で、1980 年 4 月から 1981 年 7 月にかけて 7〜10日間の間隔で調査を取扱し、優占植物プランクトン、クロロフィル a、リン（全リンおよび溶存無機リソ）、および硝酸・亜硝酸態窒素の季節変化を調査した。

1）6月から 11月にかけては緑藻がほぼつきののような順番で優占した：Closterium、Pediastrum、Staurastrum、12月から 5 月にかけては藻泥のFragilaria、Asterionella および鞭毛藻のCryptomonas が優占した。また、Melosira と Cryptomonas はほぼ 1 年を通じて優占した。

2）クロロフィル a は年間を通じて 328 μg・l⁻¹（平均 9.4）の範囲で変動したが、そのピークは春と秋に現れ、春のピークは Cryptomonas、Uroglena または Closterium の増殖によって、秋のピークは Staurastrum、Melosira または Fragilaria の増殖によって形成された。

3）全リンは年間を通じて 2085 μg・l⁻¹（平均 47）と大きく変動した。溶存無機リンは 5 月から 10 月にかけて比較的高く (340 μg・l⁻¹)、11 月から 4 月にかけて低かった (05 μg・l⁻¹)。

4）クロロフィル a と全リンないしは溶存無機リンとの間には明瞭な相関関係は認められなかった。

5）硝酸・亜硝酸態窒素は夏季にしばしば消失したが、秋の一時期を除く他の季節には高濃度（100〜300 μg・l⁻¹）に検出された。夏季に植物プランクトンの現存量が低いのは無機態窒素の欠乏によるのではないかと推定された。

References


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