Primary Production in the Downstream of the Yahagigawa River

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Introduction

The Yahagigawa River is located on the central Japan of the Pacific Coast and flows into Mikawa-Bay. Many papers concerning the water quality and standing corps of benthos in the Yahagigawa River have hitherto been reported, though no paper on the study of primary production is known. In taking some opportunities, we investigated the primary production of the Yahagigawa River for past 10 years with the water quality. The Yahagigawa River indicated high values of turbidity as a result of our observations in 1971 and 1979. The degree of value (ss) was over 100mg • 1^{-1}. Moreover, the water pollution of organic matter, BOD, is gradually increasing or keeps the same level as at the previous observation, but the values of N and P are higher than those of the Kisogawa River and the Toyogawa River. Nevertheless, the transparency is improved now. The phenomenon of eutrophication is in progress in the Yahagi River. The primary production of the Shonaigawa River has already been reported by Tanaka (1977), the Arakawa River by Tominaga *et al.* (1960), the Tamagawa by Aizaki (1978, 1979), the Yoshinogawa River by Watanabe (1975) and the kisogawa River by Yagi (1984). So, we will report the result of the primary production of the Yahagigawa River, comparing with some other rivers.

Method

The sampling locations for our ovservation are three stations shown in Fig. 1 (Yonezubashi, the Kanorigawa River, Nakahatabashi).

The observations were carried out on April 24 to 25 (spring), and July 25 (summer) in 1982. Water temperature, pH and DO (dissolved oxygen) were directly measured at each station. Samples of chlorophyll-a were determined by the fluorometric method of Holm-Hansen *et al.* (1965) and Primary Production was determined by the light and dark bottles-oxygen method (Spring : the exposure was carried out from 18 to 6 o'clock and from 6 to 15 o' clock). The mesurements of the growth rates of sessile algae were carried out by the using of artificial substrata of the polyvinyl chloride plates (14mm x 60mm). These substrata were fixed on an iron frame with clips or wires and submerged to use for each experiment. Four sampling plates for measurment were removed from the iron frame at regular intervals (4 days, 8 days, 11 days and 15 days) and analyzed at the laboratory. The plates were used for the growth rates of sessile algae and estimated from the change of the chlorophyll-a contents with the submerged times of the upper surface of the polyvinl chloride plates. The photosynthesis-light curves and P_{max} were measured by DO method

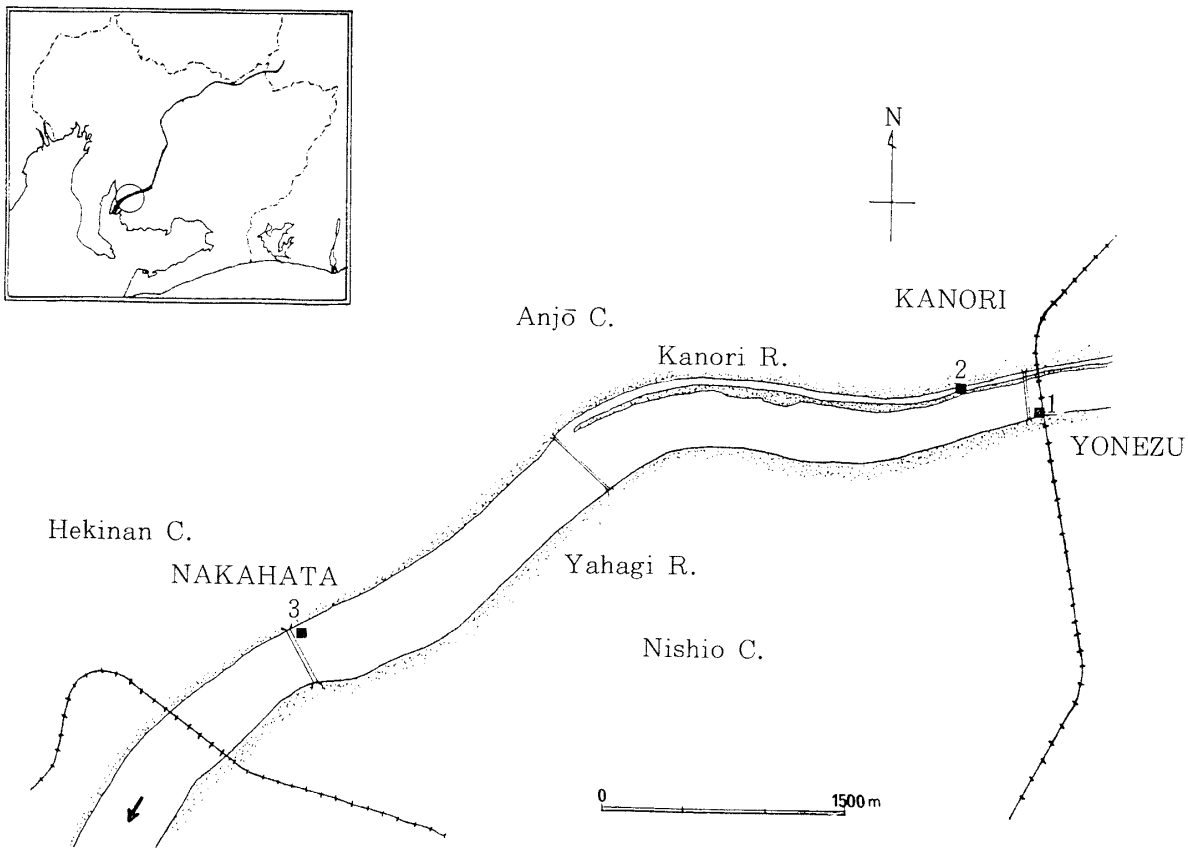

Fig. 1 Map showing the downstream of the Yahagi River.

with the samples of plates.

Result

1. General Properties

1) Water Temperature

The mean of water temperature was 19.7℃ in the Kanorigawa River, 19.0℃ at Nakahatabashi and 18.6℃ at Yonezubashi in spring. The diurnal change of temperature in Yonezubashi was the largest (maximum value-22.9℃ and minimum value-14.3℃) and those of Nakahatabashi and the Kanorigawa River slight. The diurnal changes of three stations are not clearly obtained in summer.

2) Dissolved Oxygen

The smallest mean of DO in spring was 5.70 mg • 1^{-1} in the Kanorigawa River, and at the other station were 8.46 mg • 1^{-1} in Nakahatabashi and 8.81 mg • 1^{-1} in Yonezubashi.

The diurnal change of DO from p. m. 6 to 9 and a. m. 6 to 12 in the Kanorigawa River was very great. In Nakahatabashi, the remarkable decrease of DO was not observed as well as that in the Kanorigawa River, but the remarkable increase was observed from a. m. 6 to a. m. 9. The diurnal change of DO in Yonezubashi was not detected. The minimum

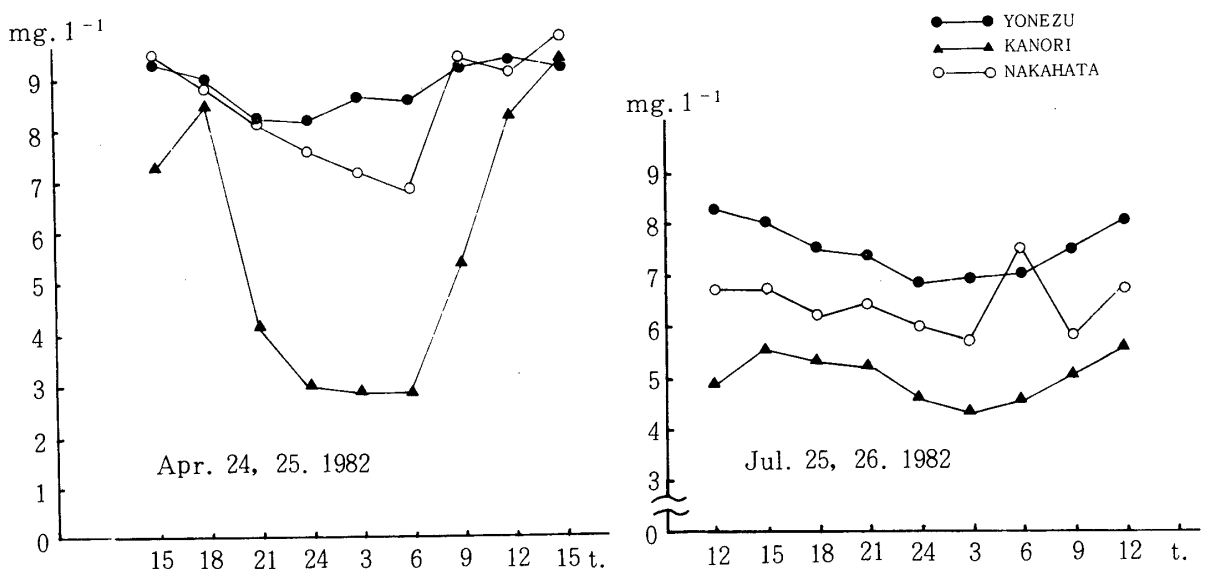

Fig. 2 Diurnal changes of DO

DO value was observed at a. m. 3 in summer regardless the sampling spots.

2. Primary Production

1) Chlorophyll-a, b, c

Chlorophyll-a and b contents of spring and summer were low, but chlorophyll-c was high in Yonezubashi. The diurnal change of chlorophyll-c was larger than that of chlorophyll-a and b, too. Cholrophyll-a content was higher than that of chlorophyll-b and c value, but that of chlorophyll-c was especially low. In summer, chlorophyll-a and c contents in the Kanorigawa River were high, but chlorophyll-b and c contents were low in three stations. As mentioned above, the most highest chlorophyll content was obtained in the Kanorigawa River.

2) Primary Production of Algae in the flowing water

The respiration of the algae in the flowing water at three stations was inactive in spring, but active in summer. The net-production in Yonezubashi was 107 $mgO_2 \cdot mgchl.a^{-1} \cdot hr^{-1}$. and the respirations were 55 $mgO_2 \cdot mgchl.a^{-1} \cdot hr.^{-1}$ and 207 $mgO_2 \cdot mgchl.a^{-1} \cdot hr.^{-1}$ in spring. It is interesting that the respiration was by far higher than the net-production. The respiration in Yonezubashi was 250 $mgO_2 \cdot chl.\ a^{-1} \cdot hr.^{-1}$ and that of the Kanorigawa River was 20 $mgO_2 \cdot chl.a^{-1} \cdot hr.^{-1}$ but the net-production was zero in summer. In case of Nakahatabashi, the respiration and net-production were 207 $mgO_2 \cdot chl.a^{-1} \cdot hr.^{-1}$ and 0. 0 $O_2mg \cdot chl.a^{-1} \cdot hr.^{-1}$ in summer, respectively, though the values were quite different from those in spring.

3) Attached Algae

The net-production in Yonezubashi was obtained 0.17 and the Kanorigawa was 0.15 $mgO_2 \cdot mgchl.a^{-1} \cdot hr.^{-1}$. That value in Nakahatabashi ($0.06mgO_2 \cdot mgchl.a^{-1} \cdot hr.^{-1}$) is about half as those of two stations. The respiration in Nakahatabashi was the highest value (0.

39 $mgO_2 \cdot mgchl.a^{-1} \cdot hr.^{-1}$) and the gross-production was same value as two other stations. The net-production was very low except Yonezubashi, and the respirations in Nakahatabashi, Kanorigawa and Yonezubashi were observed 10.4, 1.20 and 1.09 $mgO_2 \cdot mgchl.a^{-1} \cdot hr^{-1}$ respectively.

Table 1 The standing crop of attached algae

	Spring	Summer	Means
YONEZU	1,710	130	920
NAKAHATA	730	30	380
KANORI	810	130	470

mg chl.a·m^{-2}

Table 2 Photosynthetic activity of attached algae (in Laboratory method)

	Gross(Pg)	Net(Pn)	Respiration(R)
YONEZU	0.360 (8000 Lux)	0.028 (8000 Lux)	0.333
NAKAHATA	0.354 (30000 Lux)	0.044 (13000 Lux)	0.325
KANORI	0.183 (8000 Lux)	0.093 (8000 Lux)	0.187

$mgO_2 \cdot mg\ chl.a^{-1} \cdot hr^{-1}$

Discussion

1) Standing crops of attached Algae

In case of spring observation, the standing crops of attached algae were 1710 $mgchl.a \cdot m^{-2}$ (Yonezubashi), 810 $mgchl.a \cdot m^{-2}$ (the Kanorigawa River) and 730 $mgchl.a \cdot m^{-2}$ (Nakahatabashi). These values were higher than that of the Shonaigawa River, which was obtained 100−300 $mgchl.a \cdot m^{-2}$ by Tanaka (1977). The values of the Kanorigawa and Yonezubashi were lower than that of the Tamagawa River, 1000 $mgchl.a \cdot m^{-2}$ by Aizaki (1978, 1979). The value of Yonezubashi was the highest. It is suggested that the eutrophication of the Yahagigawa River is in progress.

The annual means of chlorophyll-a contents are reported to be from 5.2 to 251.9 $mgchl.a \cdot m^{-2}$ in the Yoshino River by Watanabe (1974). The higher values than that of the Yoshinogawa River was obtained in the Yahagigawa River. As for the value of the Kisogawa River, 888$mgchl.a \cdot m^{-2}$ and 736 $mgchl.a \cdot m^{-2}$ were also obtained by Yagi (1981). In case of summer, 130 $mgchl.a \cdot m^{-2}$, 130$mgchl.a \cdot m^{-2}$ and 30 $mgchl.a \cdot m^{-2}$ were observed in Yonezubashi, the Kanorigawa River and Nakahatabashi, respectively. These values were low because of the low temperature in summer.

2) Net-production and photosynthetic activity

The photosynthetic activity was measured under 3000,8000,13000 and 30000 lux. This experiment was carried out by the using of an artificial polyvinylchloride plate, while the

chlorophyll-a on the upper surface of the plates was determined. The value of net-production, 48.0 $mgO_2 \cdot m^{-2} \cdot hr.^{-1}$at 8000 lux was observed at Yonezubashi, 75.0 $mgO_2 \cdot m^{-2} \cdot hr.^{-1}$ at 8000 lux in the Kanorigawa River and 76.0 $mgO_2 \cdot m^{-2} \cdot hr.^{-1}$ at 13000 lux at Nakahatabashi was indicated.

The values of photosynthetic activity, 0.028 $mgO_2 \cdot mgchl.a^{-1} \cdot hr.^{-1}$, 0.093 $mgO_2 \cdot mgchl.a^{-1} \cdot hr.^{-1}$and 0.044 $mgO_2 \cdot mgchl.a^{-1} \cdot hr.^{-1}$ were obtained at Yonezubashi, the Kanorigawa River and Nakahatabashi, respevtively. In case of the Shonaigawa River (by Tanaka), the value of 20-50 $mgO_2 \cdot m^{-2} \cdot hr.^{-1}$ was observed in the upper stream, 100-300 $mgO_2 \cdot m^{-2} \cdot hr.^{-1}$ in the middle stream and 200-700 $mgO_2 \cdot m^{-2} \cdot hr.^{-1}$ in the lower stream. The value of the Yahagigawa River is approximately the same as that of the middle stream in the Shonaigawa River. Besides, the respirations of three staions were high, but the photosynthetic activitise of the attached algae were low.

3) Growth Rate of Algae

In Yonezubashi, chlorophll-a amounts on a slide were 830 $mgchl.a \cdot m^{-2}$ (4 days) and 1430 $mgchl.a \cdot m^{-2}$ (15 days) and the rapid growth were determined in the early stage, the growth rate during 4 days, for example, was 208 $mgchl.a \cdot m^{-2} \cdot day^{-1}$ in spring, but the total growth was 85 $mgchl.a \cdot m^{-2}$. The decrease in the growth caused by falling from the plate was observed after 11 days.

In summer, 30 $mgchl.a \cdot m^{-2}$ and 1540 $mgchl.a \cdot m^{-2}$ were observed, respectively, in 4 days and 11 days. Besides, the value was also decreased to 790 $mgchl.a \cdot m^{-2}$ in 15 days. The growth rate of algae in summer was 1.64 times as much as that in spring. in case of the Kanorigawa River, the growth rate was 750 $mgchl.a \cdot m^{-2} \cdot day^{-1}$ in spring and 30 $mgchl.a \cdot m^{-2} \cdot day^{-1}$ in summer. In Nakahatabashi, high increase in the growth rate was shown during 4 daus to 15 days in spring. This growth rate was 300 $mgchl.a \cdot m^{-2} \cdot day^{-1}$. It is interesting to note that the high increase in the growth was found after 8 days. The major reason may be due to the growth of its sea-weed in the estuary.

4) Daily change in Potosynthesis-light Curves of Algae and P_{max}

Generally, chlorophyll-a amount was 300 $mg \cdot m^{-2}$ to 500 $mg \cdot m^{-2}$ in winter and was 100 $mg \cdot m^{-2}$ to 200 $mg \cdot m^{-2}$ in the other seasons of Japanese rivers. The patterns of phytosynthesis-light curves showed a remarkable seasonal change. The curves of seasonal change of photosynthetic rate was almost the same as that of phytoplankton in the lake. That rate showed the range of 2 $mgO_2 \cdot mgchl.a^{-1} \cdot hr.^{-1}$ in winter and 12 $mgO_2 \cdot mgchl.a^{-1} \cdot hr.^{-1}$ in summer according to Tominaga *et al.* (1966).

In case of the Yahagigawa River, the photosynthetic activity may be low under the *in situ* method because of the high suspended solid (SS). We have measured the activity under the saturated light intensity in the laboratory.

The photosynthesis was the highest value after 4 days in each station. In spring, 2.25 $mgO_2 \cdot chl.a^{-1} \cdot hr.^{-1}$, 2.1 $mgO_2 \cdot chl.a^{-1} \cdot hr.^{-1}$, 2.1 $mgO_2 \cdot mgchl.a^{-1} \cdot hr.^{-1}$ and 4.85 $mgO_2 \cdot mgchl.a^{-1} \cdot hr.^{-1}$ were observed, respectively, at Yonezubashi, the Kanorigawa River and Nakahatabashi. The values were higher than those of the *in situ* method. These values are the same as in the Shonaigawa River, 2 to 7 $mgO_2 \cdot mgchl.a^{-1} \cdot hr.^{-1}$ by Tanaka *et al.*

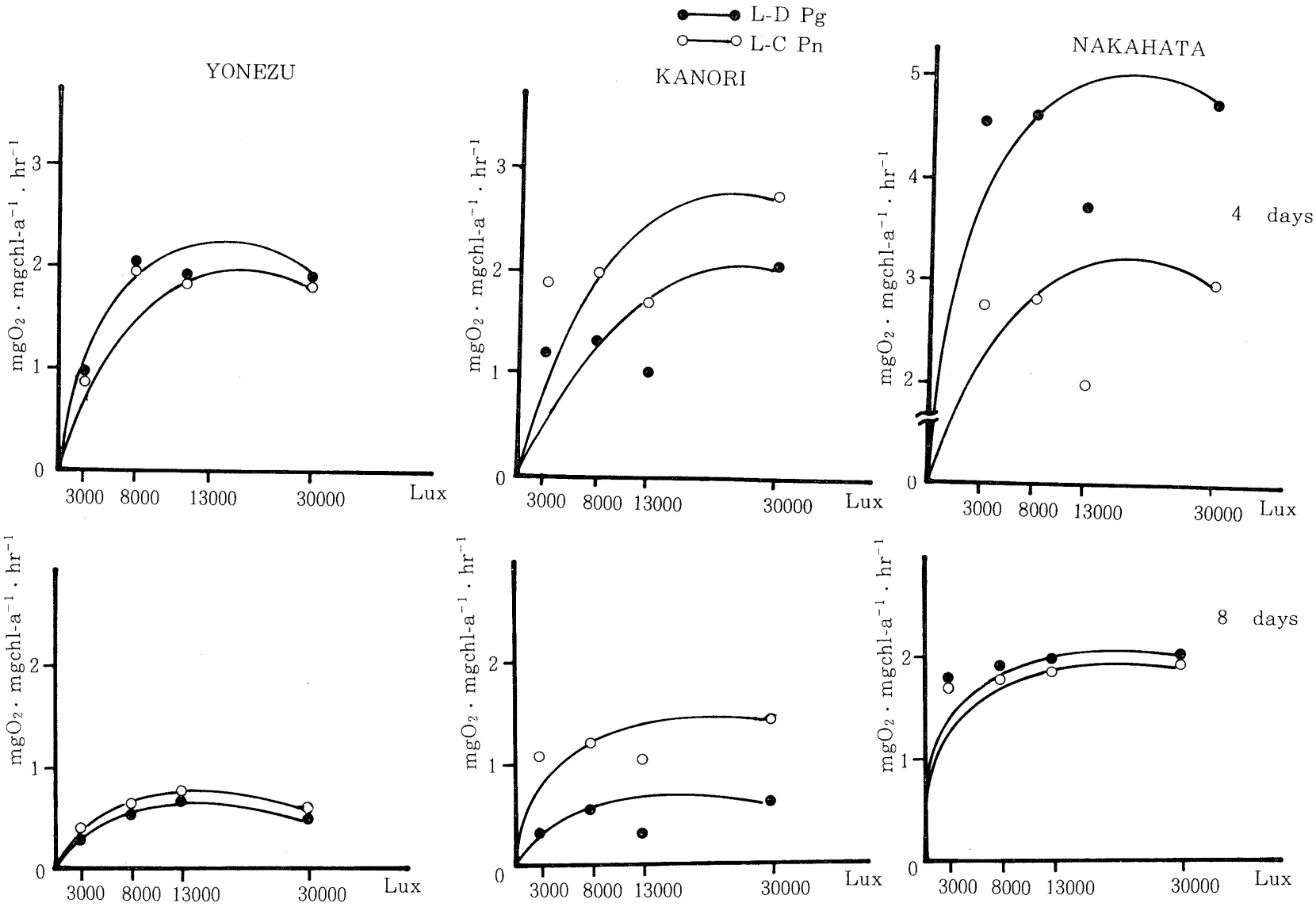

Fig. 3 — 1 Daily changes in photosynthesis–light curves of attached algae on the slides

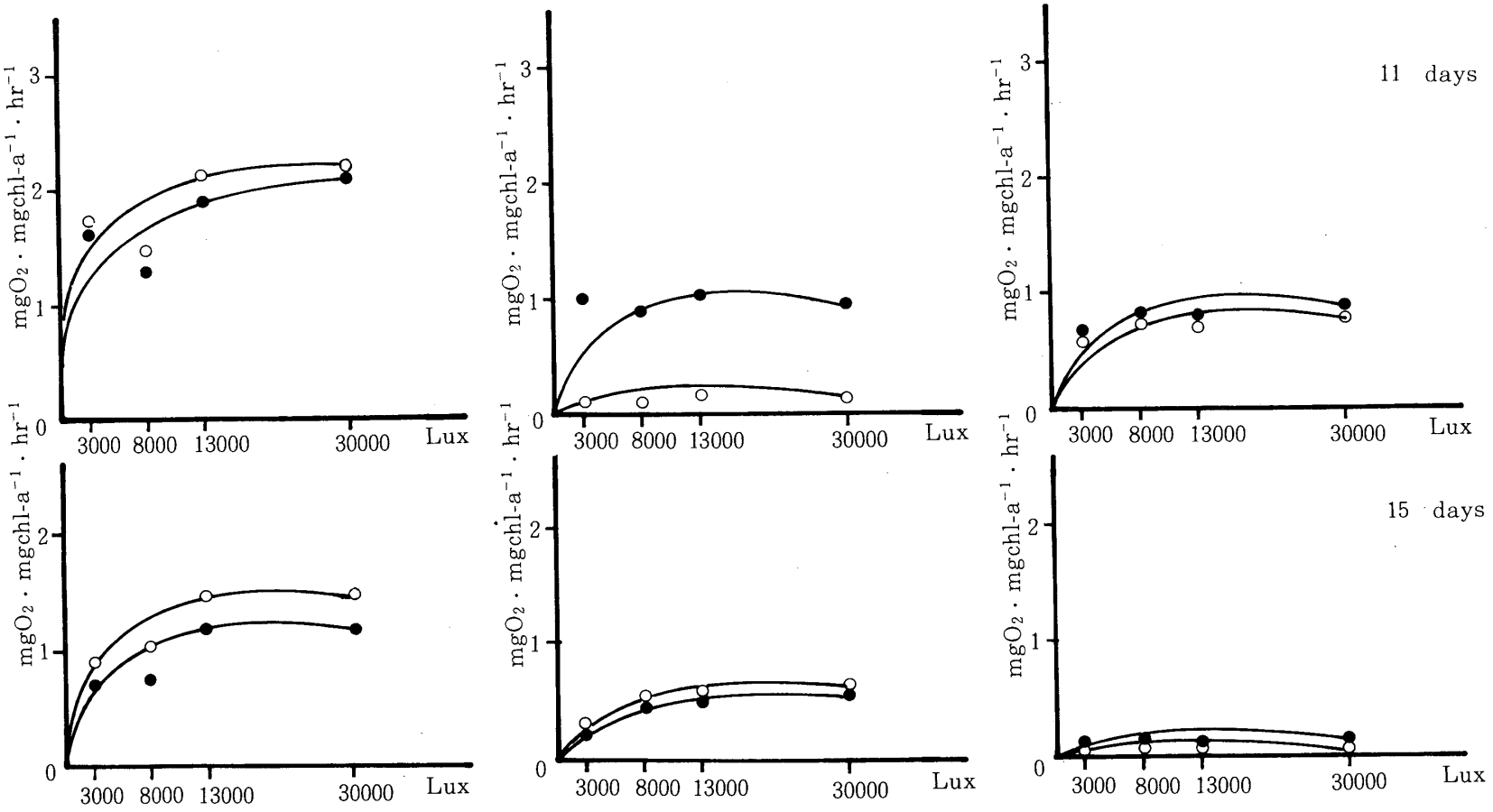

Fig. 3 — 2 Daily changes in photosynthesis–light curves of attached algae on the slides

(1977). The value of Nakahatabashi was high, 3.7 $mgO_2 \cdot mgchl.a^{-1} \cdot hr.^{-1}$, in summer and the other two stations were the same as those in spring.

The value of P_{max} was obtainted after 4 days and decreased after 8 days. It was suggested that the decrease of P_{max} is caused by falling off from the plates. Net-production and gross-production in spring and summer are as shown in Table 2. The high production in spring obtained in Yonezubashi is higher than the net-production (348 $mgO_2 \cdot m^{-2} \cdot hr.^{-1}$) and the gross-production (513 $mgO_2 \cdot m^{-2} \cdot hr.^{-1}$) in Kasamatsu (the Kisogawa River), and is one half to one third of the Shinsakae River (the Kisogawa River), G.P : 4950, N.P : 3100 $mgO_2 \cdot m^{-2} \cdot hr.^{-1}$. The productions of the other two staions are nearly the same those of as the Kisogawa River.

Acknowledgment

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要　　約

矢作川はかつて，河川の濁りが著しく，SS は約 100 ppm 以上の観測結果がある。最近では，かなり改善され，透明度も高くなりつつある。しかしながら，BOD は昭和 40 年代に比較し，横ばいないし，やや増加の傾向にあり，かつ窒素・リンは非常に大きい。この様な富栄養化の著しい矢作川下流部とその支流鹿乗川において，一次生産量を測定した。

矢作川下流部の付着藻類（付着板法）の成長量は春季の結果では，全測定期間（0～15 日間）で 73～301 $mgchl.a \cdot m^{-2} \cdot day^{-1}$であった。また，付着藻類（付着板法）の光合成活性は 2～250 $mgO_2 \cdot mgchl.a^{-1} \cdot hr^{-1}$で総生産量は 340～2100 $mgO_2 \cdot m^{-2} \cdot hr^{-1}$となり，富栄養化は著しいと考えられる。