PRIMARY PRODUCTION OF PHYTOPLANKTON AND MACROPHYTES IN AN EUTROPHIC LAGOON, LAKE KYUNGPO, KOREA

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ABSTRACT

Primary production of phytoplankton and macrophytes are measured in a eutrophic lagoon, Lake Kyungpo, where 86% of the lake is inhabited by macrophytes. Phytoplankton standing crop was high, 40-130 mgChl/m^3, but productivity per unit area was suppressed low by the light deficiency due to high content of inorganic suspended particles. Contribution of phytoplankton and macrophytes to the total annual production was 55% and 45%, respectively. Allochthonous organic input estimated from BOD was 36% of total organic matter supply.

Nitrogen seems to be the limiting nutrient for phytoplankton, since nitrate is often depleted in the water column of macrophyte-growing region and N/P ratio is low. Turbulence and the vertical transfer of oxygen and nutrient are strongly suppressed by the dense population of macrophytes and the chemocline of high stability caused by saline bottom water.

KEYWORDS;phytoplankton, macrophytes, standing crops, P-I model, Lake Kyungpo

INTRODUCTION

Lake Kyungpo is a eutrophic lagoon located at the eastern coast of Korea. Dense macrophyte population is developed all over the lake because of the shallow depth, less than 1m except the dredged area. The pollutant sources in the watershed increased recently and the water quality is deteriorated. Lake Kyungpo receives sewage from the recreational resort along the shore, a university newly-built just upstreamward, and agricultural discharge. Most of sewage is not treated properly and causes eutrophication of Lake Kyungpo, which results in the high density of phytoplankton, turbid water, flourishing macrophyte population, and bad smells from the anaerobic sediment.

In this study organic matter budget was studied by measuring the primary production of phytoplankton and macrophytes and the allochthonous organic input.

MATERIAL AND METHODS

Primary productivity of phytoplankton is measured at one site by C-14 P-I model method described by Kim and Kim(2). C-14 uptake are measured at 6 different light intensity attenuated by neutral nylon screen submersed at the shore to keep temperature same as the surface water. Incubation period was 2 hours near noon to have light intensity of less variation. P-I curves were fitted to the P-I model of Platt et al.(5) by the least square method and the model parameters are determined. The light extinction coefficients are calculated by measuring underwater light intensity at 10cm depth interval.

Primary production of macrophytes were estimated from the maximum standing crop of the year corrected for underground biomass, dead leaf loss, and respiration loss. The correction factors are not measured in this study, but approximated from the cited values of other research as given in Table 1. Macrophyte-covered region is divided into two part; one for emergent macrophytes dominated by *Zizania latifolia* and the other for floating leaved macrophytes dominated by *Trapa japonica*. Two different corrections of losses are employed for each region. Standing crops are measured by harvesting above-ground shoots within 1m^2 quadrat manually at

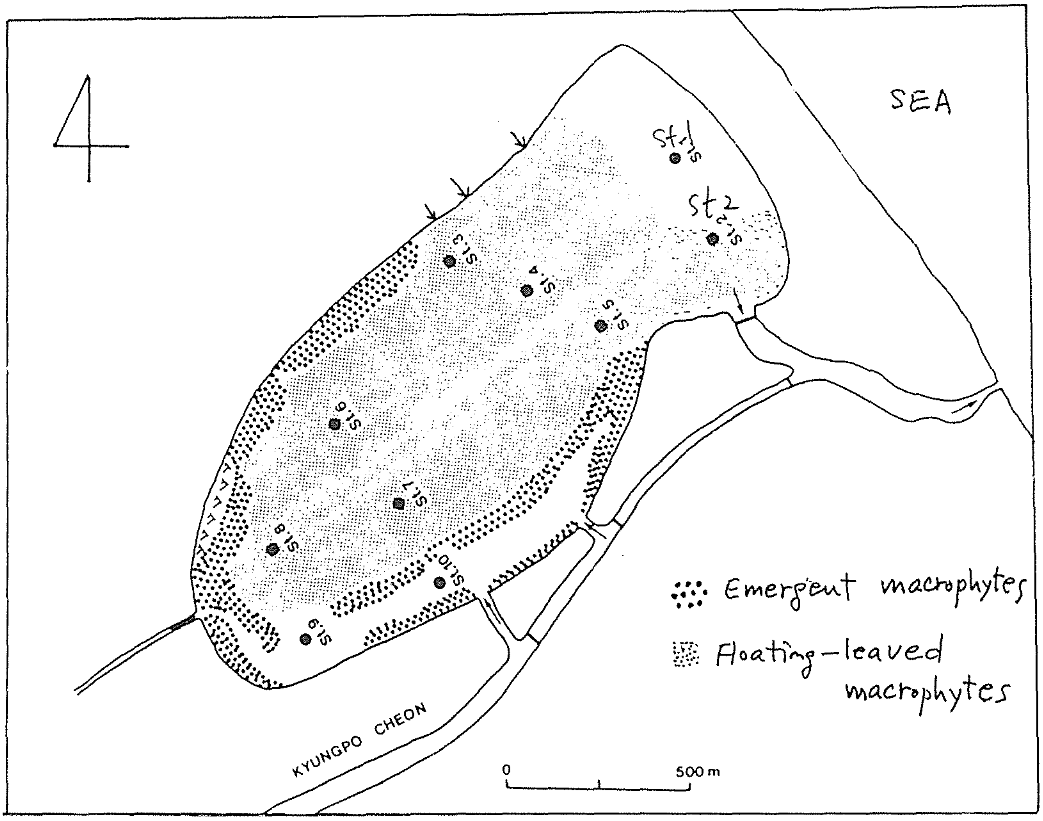

Fig.1 Map showing the sampling sites and macrophyte distribution in Lake Kyungpo.

8 stations for floating-leaved and 3 stations for emergent macrophytes. Triplicate smples are transfered to the lab and dried for dry weight measurement. Total production in Lake Kyungpo was calculated by multiplying the gross productivity per m^2 and the area of the two regions.

Oraganic carbon input through the inflowing stream and sewage discharge were estimated from the BOD measurement because organic carbon data were not available. It is assumed that 50% of total organic matter is decomposed in the 5-day BOD measurements and 1 molecule of oxygen is consumed for one atom of organic carbon decomposed. Flow rate of inflowing streams and sewage discharge were measured by the weir method.

Water samples were collected on the monthly base at 50 cm depth interval with PVC Van Dorn type water sampler and transported in polyethylene bottles. Samples were filtered through GF/C glass filters within the sampling day. Filter papers were stored frozen for the analysis of chlorophyll. Concentrations of chlorophyll were determined by the spectrophotometric method of Lorenzen(3). Total phosphorus and total nitrogen were determined after persulfate digestion by ascorbic acid method and cadmium reduction method, respectively (1).

RESULT AND DISCUSSION

P-I model parameters for phytoplankton are presented in Table 1. Productivity was highest in September, though chlorophyll was highest in May. Chlorophyll concentration was very high, much over the boundary of

Table 1. P-I model parameters and primary productivity of phytoplakton.

	α	β	Ps	AN	AP	EC	Chl.a
May	13.7	0.000	1.9	1.9	1182	7.98	127.5
Jun	10.9	0.462	3.8	3.2	1071	5.63	58.4
Sep	39.8	5.230	11.2	7.5	3464	4.07	44.1
Nov	28.6	0.000	3.2	3.2	835	4.00	40.6

α : The initial slope of P-I curve at the low light level ($gCm^2/gChl/E$)
β : The photoinhibition coefficient of P-I curve at the high light level ($gCm^2/gChl/E$)
Ps : The maximum potential photosynthetic rate at saturation light level without photoinhibition (gC/gChl/hr)
AN : Assimilation number or activity coefficient of chlorophyll a (gC/gChl/hr)
AP : Productivity per unit area($mgC/m^2/day$)
EC : Extinction coefficient (1/m)
Chl.a : Concentration of chlorophyll a (mg/m^3)

Table 2. Standing crop of floating leaved macrophytes, nitrate-N concetration, and TN/TP atomic ratio in Lake Kyungpo.

St.	Standing crop (gDW/m^2)		NO3-N(mg/1)		TN/TP
	June	Sep	June	Sep	June
1	0	0	0.122	0.320	24.9
2	4	70	0.097	0.235	23.7
3	32	9	0.000	-	14.6
4	14	96	0.000	0.298	-
5	506	-	0.000	0.567	14.6
6	183	106	0.024	0.370	16.0
7	-	85	0.092	1.223	17.4
8	155	90	0.128	1.205	12.8
9	218	108	0.608	1.386	37.8
10	0	0	0.793	1.324	28.5

eutrophy. However, productivity per unit area is not so high because of low light penetration due to high concentration of inorganic suspended particles, about 50% of total SS(7).

The standing crop of floating-leaved macrophytes is given in Table 2. The emergent macrophyte community was composed of 3 major species but the floating-leaved macrophyte community was completely dominated by one species, Trapa japonica. In the past 20 years the dominant species of macrophyte community has been changed very much; from Potamogeton crispus, Ceratophylum demersum, Myriophylum verticillatum to Trapa japonica, Zizania latifolia, Typha orientalis, and Nelumbo nucifera. It is not certain that this succession is caused by the eutrophication or the salinity change due to the construction of watergate at the outlet to the sea partly reducing water exchange with sea. However, the former is thought to be major.

Productivity of floating-leaved Trapa japonica per unit area was at the simmilar level with phytoplankton, but the productivity of emergent

Table 3. Data for the calculation of gross primary production by macrophytes. Harvest, corrections for losses, and productivity.

	floating-leaved macrophytes	emergent macrophytes
Average maximum above-ground standing crop (gDW/m^2)	186	700
Senescence (%)*	35	30
Underground biomass (%)**	30	30
Respiration loss (%)***	25	25
Carbon/dry weight (gC/gDW)	0.45	0.45
Productivity ($gC/m^2/yr$)	245	857
Coverage (m^2)	690,000	165,000
Gross production (tC/yr)	169	141

* 34% for emergent, 39% for floating-leaved(4), 19% for shoots of Typha latifolia(6); ** 8% for Zizania aquatica, 30-70% for floating-leaved(6), 23% for Trapa japonica(4); *** (6)

Tble 4. The budget of organic matter in Lake Kyungpo.

sources		loading(tC/yr)	percentage
Allochthonuous organic matter		370	35 %
Primary production of phytoplankton		372	36 %
Primary production of mactophytes		310	29 %
Floating-leaved	169		
Emergent	141		
Total		1052	100 %

macrophytes, Zizania latifolia, was much higher than phytoplankton. Primary production by macrophytes contribute 44 % of total production. This portion is high for a lake, which is ascribed to wide littoral zone. In Lake Kyungpo the whole lake basin is littoral zone except small strips of dredged area.

With the productivity of phytoplankton and macrophytes added, autochthonous organic matter production contribute 65% of total organic matter input which is twice as large as the allochthonous origin. Therefore the removal of only organic carbon from the sewage without advanced treatment would not be effective for the water quality improvement in Lake Kyungpo.

The limiting nutrient of phytoplankton seems to be nitrogen. Though the TN/TP atomic ratio is not lower than the average algal composition (Table 2.), nitrate depletion is observed in the central part of the lake. Whereas the dissolved inorganic phosphorus is not depleted(7). Phytoplankton is under the competetion for nitrogen and light with macrophytes. Macrophytes have some advantage because dissolved inorganic nitrogen is often depleted in surface water layer (Table 2.) but ammonia is rich in the anoxic bottom layer where macrophytes can absorb nutrients.

Light deficiency also seem to be an important limiting factor for phytoplankton and submersed macrophytes. Floating-leaved and emergent macrophytes have obvious advantage. The coverage of lake surface by floating-leaves measured by photograph analysis was average 40% in growing season. The reduction of submersed macrophytes in the past decades seem to be due to the high turbidity. And, in turn, the high turbidity is thought to be caused by both eutrophication and the reduction of hydraulic flushing rate due to the diversion of part of inflowing stream directly into the sea.

Strong vertical chemocline is observed in Lake Kyungpo with large difference of DO, conductivity and nutrients between surface and deep water. Surface layer is oxic and, and the deep water below 1m depth is anoxic. Dense macrophyte population suppress vertical turbulence by wind and the transfer of oxygen. The saline water at the bottom enhances the stability of chemocline. Salinity of surface is negligible but below the chemocline it goes up to 1/3 of seawater. Temperature does not seem to be critical in the formation of chemocline, since inverse temperature profiles are sometimes observed.

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