Kor. Turfgrass Sci., 10(2), 143~150, 1996

# The Removal Rates of the Constituents of Litters in the Littoral Grassland Ecosystems in the Lake Paldangho
# Ⅰ. Organics

**Shim, Kew-Cheol, Kyoung-Mi Kang and Nam-Kee Chang**

*Department of Biology Education, Seoul National University*

# 팔당호 연안대 초지생태계에서 낙엽 구성성분의 유실률
# Ⅰ. 유기물

**심규철 · 강경미 · 장남기**

서울대학교 사범대학 생물교육과

## ABSTRACT

The removal rates of gross production and organic matters were investigated in the Lake Paldangho. In 1995 and 1996, soils and litter samples were collected and annual mean production and removal rates were calculated. Communities in the Lake Paldangho were *Phragmites communis*, *Miscanthus sacchariflorus*, *Typha angustata* and *Scirpus tabernaemontani*. Removal constants of aquatic plant communities estimated by the mathematical theoretical models, were 0.826, 0.567, 0.571 and 0.751, respectively. The durations of reaching half of initial organic amounts were 0.839 yeras, 1.221 years, 1.213 years and 0.922 years respectively at the steady state of removal and accumulation for organics. For organics, the rapidity of removal were more speedy *P. communis*, *S. tabernaemontani*, *T. angustata*, *M. sacchariflorus* in order. The times needed for 99% removal were 6.051 years, 6.651 years, 8.752 years and 8.811 years, respectively.

**Key words:** Gross production, Organic matters, Lake Paldangho, *Phragmites communis*, *Miscanthus sacchariflorus*, *Typha angustata*, *Scirpus tabernaemontani*., Removal constants.

## INTRODUCTION

Aquatic plants are important in oxygen production, nutrient cycling, controlling water quality, sediment stabilization and providing habitat and shelter for aquatic life and wildlife. The community dynamics of aquatic plants can affect the quality of drinking water and recreational use of water body. Aquatic plants have been used to remove suspended solids, nutrients, heavy metals, toxic organics and bacteria from urban stormwater runoff. Also, they can absorb a portion of nutrients and metal ion.

Aquatic plant ecosystem has taken the function of self-purification. Lewis(1995) reported that aquatic macrophytes could been used as bioremediators of domestic and industrial waste waters and as biomonitors of polluted environments. Warren *et al.* (1995) studied on the effects of competition between organics and iron oxide, and between cadmium and copper in the artificial oxide-organic sediment. Organics controlled the partitioning and bioavailibility of copper. Kim and Cho(1991) investigated the difference of the sink and source of nitrogen and phosphorus in the Lake Paldangho, Korea and suggested that aquatic macrophytes had harvested repeatedly to improve of water quality. In the littoral zone of Paldangho, the growth of macrophytes has been effected by chemical characteristics of sediment and water(Cho *et al.*, 1994). Cho and Kim(1994) suggested that *Zizania latifolia*, aquatic macrophyte, had growth strategy to water depth. They reported that the standing crop of shoots and the height of them increased with water depth, but the density decreased.

Since models of decay and accumulation of litters of plants were suggested by Jenny (1949), Olson(1963) mathematically quantified accumulation in plant communities according to income and output of litters and suggested the methods to determine the decay constants. Chang and Yoshida(1973) reported the decay system of litters. On the base of his models, otherwise opinions that Kim and Cho(1991) suggested, Chang *et al.* (1987) suggested the mathematical models of the litter accumulation, decay and turnover in the grassland and forest ecosystems. Chang *et al.* (1995a, b) investigated the decay of the litters in the terrestrial grasslands ecosystems. They suggested the theoretical model and reported the decay constants. Chang and Ahn(1995) and Chang and Oh(1995) calculated removal constants on theoretical decay model adapted to *Phrgamites* grasslands in delta area of the Nakdong River, Korea. This study was practiced in the littoral zone of the Lake Paldangho

## MATERIALS AND METHODS

### 1. Study area

The lake Paldangho is located in Namyangju-gun Choan-myun, Kyounggi-do, Korea. Aquatic plant ecosystems were investigated in the littoral zone near the Bridge Yangsu (Fig. 1). Plant communities in the study area were, *Phragmites communis, Miscanthus sacchariflorus, Typha angustata, Scirpus tabernaemontani, Athroraxon hispidus, Salix koreensis* and *Oenanthe japonica* in the littoral zones. There are the farm to cultivate unpolluted vegetables and paddy fields near this area. Macrophytes in the lake Paldangho were investigated; from inside of littoral zone to outside, *Typha angustata, Miscanthus sacchari-*

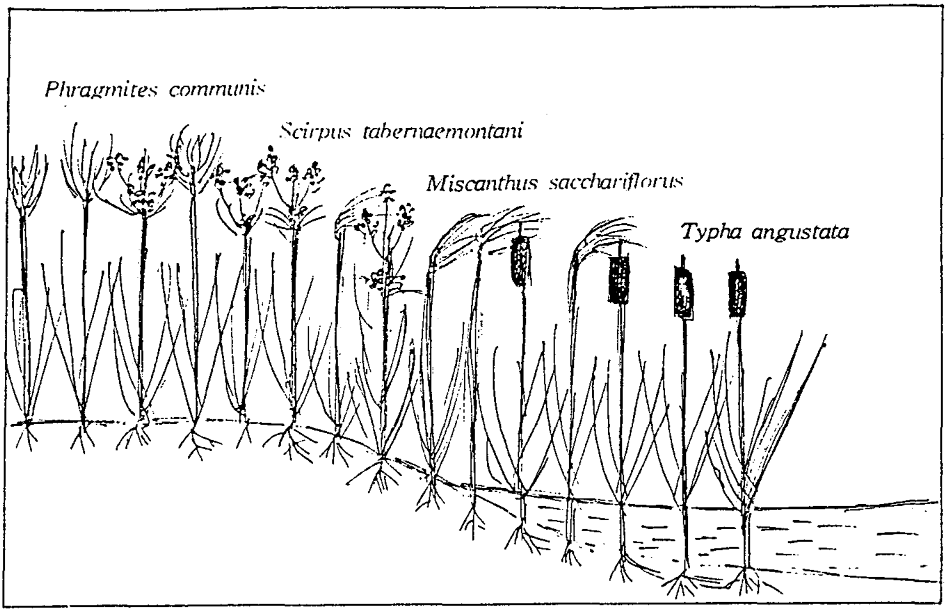



**Fig. 1.** Map showing study area.

*florus, Scirpus tabernaemontani, Phragmites communis*(Fig. 2).

**2. Methods**

Soil samples were obtained from each community, *Phragmites communis, Miscanthus sacchariflorus, Typha angustata,* and *Scirpus tabernaemontani* in 1995 and 1996. Quadrat(0.25 by 0.25cm) sampling method was used. Biomass was calculated as weights of air-dried fractions. The amounts of organic matters were determined by loss of ignition; ignite at 450℃ for 4 hours in the furnace.

Production, decay and accumulation of the litters in the aquatic plant ecosystems, and removal constants(r) were calculated on the base of experimental and theoretical models suggested by Chang and Ahn(1995) and Chang and Oh(1995).

## RESULTS AND DISCUSSION

In the littoral aquatic plant ecosystems in the lake Paldangho, annual production and decay of the litters of *P. communis, M. sacchariflorus, T. angustata* and *S. tabernaemontani* were showed in the Table 1 and 2. Annual gross production of each communities were as; 3,550.4g /$m^2$ in *P. communis*, 3,440.0g /$m^2$ in *M. sacchariflorus*, 8,308.8g /$m^2$ in *T. angustata* and 6,136.0g /$m^2$ in *S. tabernaemontani*.

Removal of each community in the aquatic ecosystem was calculated on the biomass

**Table 1.** Annual production of grassland ecosystem in the Lake Paldangho

| Species | Horison | Dry weight(g /m²) | Organics (%) |
|---|---|---|---|
| *Typha angustata* | *L* | 8,308.8 | 96.33 |
| | *Css* | 7,557.6 | 65.73 |
| *Miscanthus sacchariflorus* | L | 3,440.0 | 96.92 |
| | *Css* | 2,728.9 | 93.12 |
| *Phragmites communis* | *L* | 3,550.4 | 94.14 |
| | *Css* | 810.4 | 86.71 |
| *Scirpus tabernaemontani* | *L* | 6,136.0 | 97.19 |
| | *Css* | 3,111.2 | 63.28 |

and organic matters. For gross production, durations of the litter decay were shorter *P. communis*, *S. tabernaemontani*, *M. sacchariflorus*, *T. angustata* in order. Those of organics decay were shorter orderly *P. communis*, *S. tabernaemontani*, *T. angustata*, *M. sacchariflorus* (Table 2 and Fig. 3). Chang *et al.* (1995b) reported that the time of decay of organics to half amounts was 2.1 years in the *M. sinensis* in Mt. Kwanak. In this study communites,

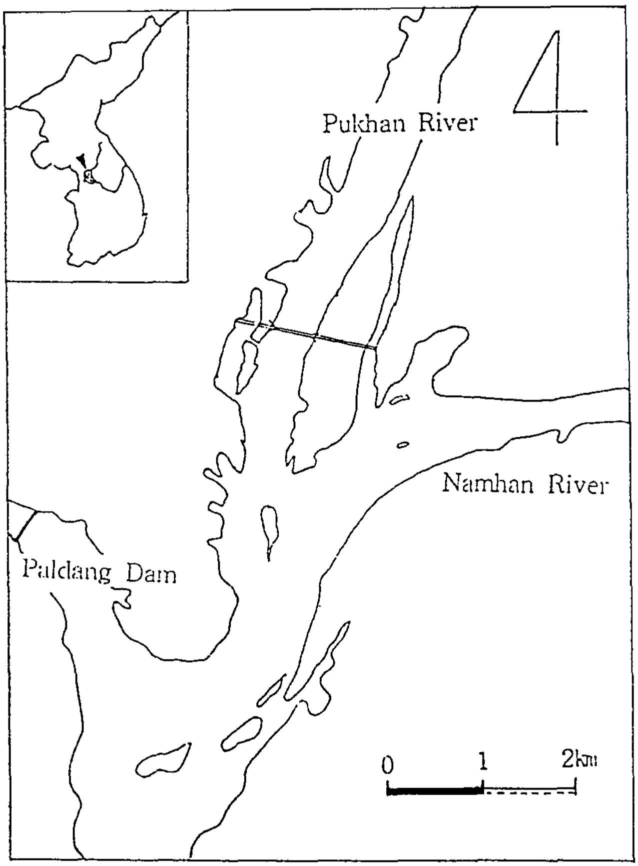



**Fig. 2.** Grassland communities of the littoral zones in the lake Paldangho.

*M. sacchariflorus*, the time of half decay was 1.2 years. For *P. communis*, the time of half decay was only 1/4 of that of *M. sinensis* in Mt. Kwanak.

Parameters of accumulation and removal on the grassland floors in the lake Paldangho are shown in Table 3. And estimation of gross production and organics is shown as Fig. 3. Removal constants for annual gross production were 0.814 in *P. communis*, 0.558 in *M. sacchariflorus*, 0.524 in *T. angustata* and 0.664 in *S. tabernaemontani* and for organics, 0.826 in *P. communis*, 0.567 in *M. sacchariflorus*, 0.571 in *T. angustata* and 0.752 in *S. tabernaemontani*, respectively.

Removal constants of organics in the aquatic plant communities are 2.5~4.5 times as those in *Pinus rigida* and *Sasa* sp. forests(Chang *et al.*, 1986). Chang and Park(1986) reported similar results with such that. Decay in aquatic communities was more rapidly than in terrestrial communities because of flowing by water current and microbes habitant in the littoral zones. While most of organic fractions of plants were stored on the top soil layers in terrestrial plant ecosystem and decomposed by microbes, in aquatic ecosystem most of them were flowed by water current, flood or downpour.

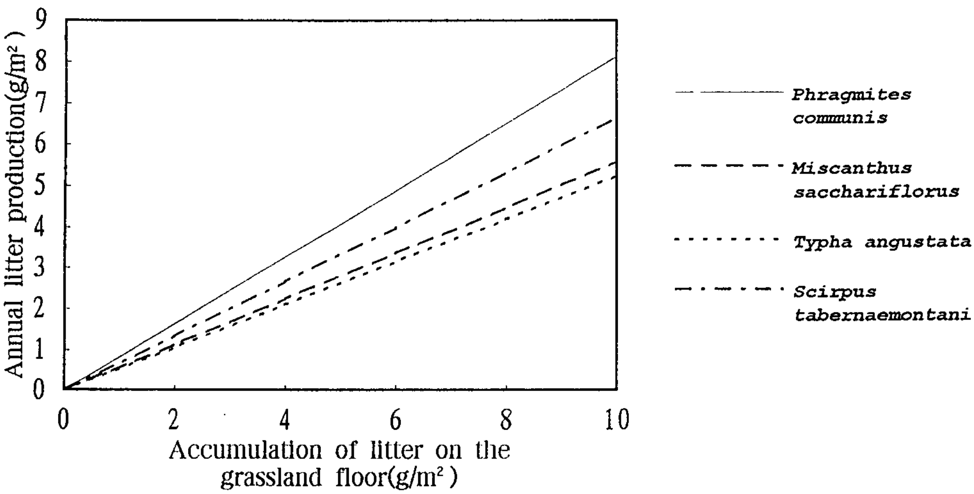
Chang and Oh(1995) investigated the removal constants of organics of litter in the grassland in the delta area of the River Nakdong. They reported that the removal constants was 0.884 in *P. longivalvis* communities(Fig. 3). This was almost same as removal constants of organics in the littoral communities in the lake Paldangho.

While in the Delta area of the Nakdong River, total organic contents of *P. longivalvis* were 2,175.4g/$m^2$(Chang and Oh, 1995), those of *P. communis* were 4,061.25g/$m^2$ in the littoral zones of the lake Paldangho. However, total organics in the one were more than the other, organics was removed more rapidly in the Nakdong River; removal constants of organics of the Delta of the Nakdong River and the littoral zones of the lake Paldangho, 0.883 and 0.828, respectively.

Chang *et al.* (1995b) reported that total organics was 2,650.8g/$m^2$ and decay constant was 0.33 in the *M. sinensis* commuity in the Mt. Kwanak. Total organic matter contents and removal constant of *M. sacchariflorus* community in the littoral zones of the lake Paldangho, were 5,944.0g/$m^2$ and 0.567 respectively. Annual production in the aquatic ecosystem was more than in the terrestrial ecosystem. Also, removal of litters was more speedy in the aquatic ecosystem. Periods of 99% decay were 15.2 years in Mt. Kwanak and 8.8 years in the lake Paldangho. Annual accumulation and decay of litter fall was leaching and winds in the terrestrial communities while in the aquatic communities such

**Table 2.** Duration of accumulation and removal on the grasslands in the lake Paldangho

| species | Biomass(year) | | | Organics(year) | | |
|---|---|---|---|---|---|---|
| | $t_{0.50}$ | $t_{0.95}$ | $t_{0.99}$ | $t_{0.50}$ | $t_{0.95}$ | $t_{0.99}$ |
| *Typha angustata* | 1.323 | 5.725 | 9.542 | 1.214 | 5.254 | 8.757 |
| *Miscanthus sacchariflorus* | 1.243 | 5.376 | 8.961 | 1.222 | 5.291 | 8.818 |
| *Phragmites communis* | 0.851 | 3.686 | 6.143 | 0.839 | 3.632 | 6.053 |
| *Scirpus tabernaemontani* | 1.044 | 4.518 | 7.530 | 0.922 | 3.989 | 6.649 |



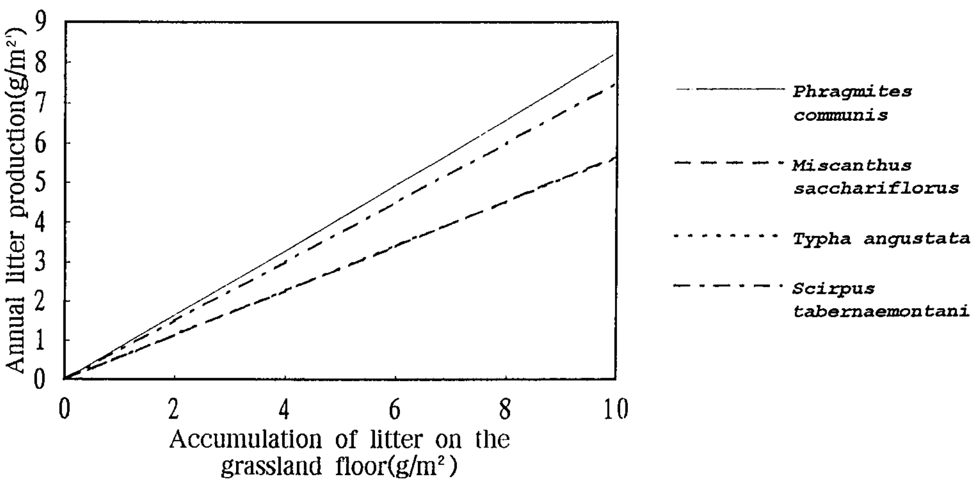




**Fig. 3.** Estimates of removal fraction r for biomass(A) and organics(B) in the grasslands from the ratio of annual addition, A, to the approximately steady state accumulation of the grassland floor, Css.

as littoral zones and Delta area, was effected on by litter being drifted by water current, tidal current and flood. Thus there was smaller accumulation of litter in the aquatic communities.

Ostendrop(1995) studied on the estimation of mechanical resistance of lakeside reed stands. The power of resistance of reed stands against waves and drifting matter was assessed. In Korea, there are many reedbelts in riversides and lakesides. The power of resistance and the mean annual load of pollutants are estimated and annual production and decay or removal constans are calulated. Powers of self-purification of reedbelts in rivers and lakes are predicted.

## 적 요

팔당호 연안대의 수생 초지생태계에서의 생산량과 유기물에 대한 유실률에 대하여 조사하였다. 1995년과 1996년에 걸쳐 토양과 낙엽을 채취하였다. 팔당호 연안대의 식물군락은 갈대(*Phragmites communis*), 물억새(*Miscanthus sacchariflorus*), 애기부들(*Typha angustata*)과 방울고랭이(*Scirpus tabernaemontani*)이며, 유실상수는 수학적 이론적 모델을 기초로 하여 산출하였다. 유기물에 대한 유실상수는 각각 0.826, 0.567, 0.571, 0.751이다. 평형상태에서 초기 유기물에 대한 반감기는 각각 갈대 0.839년, 물억새 1.221년, 애기부들 1.213년, 방울고랭이 0.922년으로 유실은 갈대, 방울고랭이, 애기부들, 물억새 순으로 빠르게 진행되는 것을 알 수 있다. 초기 유기물에 대한 99% 유실에 소요되는 기간은 갈대 6.051년, 방울고랭이 6.651년, 애기부들 8.752년, 물억새 8.811년으로 조사되었다.

## REFERENCES

1. Chang, N. K., H. B. Kim and J. H. Yoo. 1986. A study on the decomposition of litter and the leaching of mineral nutrients in the stands of *Pinus rigida* on Mt. Gwanak and *Pseudosasa japonica* on Odong-do. Korean J. Ecol., 9(2):51-58.
2. Chang, N. K., J. S. Kim, K. C. Shim and K. M. Kang. 1995a. The Energy flow and mineral cycles in a *Zoysia japonica* and *Miscanthus sinensis* ecosystem on Mt. Kwanak. 1. The standing crop and production structure. Korean J. Turf. Sci., 9(2):101-107.
3. Chang, N. K., J. S. Kim, K. C. Shim and K. M. Kang. 1995b. The Energy flow and mineral cycles in a *Zoysia japonica* and *Miscanthus sinensis* ecosystem on Mt. Kwanak. 2. Organic matter synthesis and decomposition balance. Korean J. Turf. Sci., 9(2):109-117.
4. Chang, N. K., S. K. Lee, B. S. Lee and H. B. Kim. 1987. The Litter accumulation, decay and turnover models and their validation. Korean J. Ecol., 10(3):139-149.
5. Chang, N. K. and B. H. Ahn. 1995. The removal rate of constituents of the litters in the aquatic plant ecosystems. Ⅱ. N, P, K, Ca and Na of the litter in *Phragmites longivalvis* grasslands in a delta of the Nakdong River. Korean J. Turf. Sci., 9(4):343-350.
6. Chang, N. K. and K. H. Oh. 1995. The removal rate of constituents of the litters in the aquatic plant ecosystems. Ⅰ. *Phragmites longivalvis* grasslands in a delta of the Nakdong River. Korean J. Turf. Sci., 9(4):331-342.
7. Chang, N. K. and Y. W. Leem. 1986. Comparison of the pine litter decomposition and microbial population change at Youngwal with those at Sinlim. Korean J. Ecol., 9(1):9-18.
8. Chang N. K., and S. Yoshida. 1973. Studies on the gross metabolism in a *Sasa paniculata* type grassland Ⅲ. The decay system of the litter. J. Japan Grassl. Sci.,

19:341-357.

9. Cho, K. H., S. K. Park and J. H. Kim. 1994. Reactions of macrophytes on sediment and water in the littoral zone of Lake Paldangho. Korean J. Limnology, 27(1):59-67.
10. Cho, K. H. and J. H. Kim. 1994. Comparison of shoot growth in the populations of *Zizania latifolia* along water depth. Korean J. Ecol., 17(1):59-67.
11. Grassland, D. J., and P. H. Nye. 1956. Increases in the carbon and nitrogen content of tropical soils under natural fallows. J. Soil Sci., 10:284-299.
12. Howes, B. L. and J. M. Teal. 1995. Nutrient balance of a massachusetts cranberry bog and relationships to coastal eutrophication. Environ. Sci. Technol., 29:960-974.
13. Jenny Hans, S. P. Gessel and P. T. Bingham. 1959. Comparative study of decompostion rates of organic matter in temperature and tropical regions. Soil Sci., 10:400-432.
14. Kim, C. M., and N. K. Chang. 1975. The decomposition rate of pine and oak litters affecting the amount of mineral nutrients of forest soil in Korea. The collection of papers in commemoration of the sixty anniversary of Dr. Kim's birth:104-111.
15. Kim, J. H. and K. H. Cho. 1991. Perspectives of water quality improvement by aquatic macrophyte as nutrient sink in the Lake Paldangho, Korea. Rep. Suwa. Hydrobiol., 7:167-175.
16. Lee, W. S. and N. K. Chang. 1995. Decomposition models of the organic matters in cultural media and the litters in forest. Korean J. Turf. Sci., 9(2):109-129.
17. Lewis, M. A. 1995. Use of freshwater plants for phytotoxicity testing: a review. Environmental Pollution, 87:319-336.
18. Major, J. 1951. A functional, factorial approach to plant ecology. Ecology, 32(3):392-412.
19. Olson, J. S. 1963. Energy storage and the balance of producers and decomposers in ecological system. Ecology, 44:322-330.
20. Ostendrop, W. 1995. Estimation of mechanical resistance of lakeside *Phragmites* stands. Aquatic Bot., 51:87-101.
21. Warren, L. A., P. M. Outridge and A. P. Zimmerman. 1995. Geochemical partitioning and bioavailability of copper to aquatic plants in an artificial oxide-organic sediment. Hydrobiologia, 304:197-207.