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The Removal Rates of the Constituents of the Litters in the Littoral Grassland Ecosystems in the Lake Paldangho Ⅳ. Sulphur

Kim, Yong-Jin, Shin-Seon Yoon and Nam-Kee Chang

Department of Biology Education, Seoul National University

팔당호 연안대 초지생태계에서 낙엽 구성성분의 유실률 Ⅳ. 황

김용진 · 윤신선 · 장남기

서울대학교 사범대학 생물교육과

ABSTRACT

This study was carried out to investigate the removal rate of sulphur of the litters in the *Phragmites communis, Scirpus tabernaemontani, Miscanthus sacchariflorus* and *Typha angustata* aquatic grassland ecosystem on the lake Paldangho. The annual litter productions of sulphur were 50.91 g/m^2 in *P. communis*, 180.83 g/m^2 in *S. tabernaemontani*, 25.87 g/m^2 in *M. sacchariflorus* and 151.39 g/m^2 in *T. angustata*, respectively.

The removal rates, *r*, of sulphur in the litters were 0.86 in *P. communis*, 0.82 in *S. tabernaemontani*, 0.43 in *M. sacchariflorus* and 0.47 in *T. angustata* respectively. The times required to reach 50, 95 and 99 percent of the steady state levels and turnover values of sulphur on the grassland floor were 0.81, 3.49 and 5.82 years in the *P. communis*, 0.85, 3.68 and 6.13 years in the *S. tabernaemontani*, 1.62, 7.00 and 11.67 years in the *M. sacchariflorus* and 1.49, 6.44 and 10.73 years in the *T. angustata*.

It is considered that the high removal rates of sulphur in four grasslands of aquatic ecosystem contribute to the efficient removal of sulphur, a pollutant, at the lake Paldangho.

Key words: Removal rate, Accmulation, Paldangho, Sulphur, *Phragmites communis, Miscanthus sacchariflorus, Scirpus tabernaemontani, Typha angustata.*

INTRODUCTION

To describe the phenomena of decomposition and accumulation of the litters, numerous investigators (Greenland and Nye, 1956; Jenny *et al.*, 1959; Olson, 1963; Chang and

Yosida, 1973; Kim and Chang, 1975; Chang *et al.*, 1987) have constructed a mathematical model. The ratio of annual production and decomposition of litters has used as a reliable index to evaluate the mineral nutrient cycle in the ecosystem.

In aquatic plant ecosystems, soil nutrients can be supplied by organic matter such as litter. Most of the supplied nutrients are lost not only by decomposition of litters but also by the precipitation and the flow of water(Oohara *et al.*, 1971c). The removal rate of the litter in the aquatic grassland ecosystems may also apply on the index for evaluating the removal of the water pollutants such as organic and inorganic matters. There are few reports about the addition and decomposition of the constituents of litters in aquatic grassland ecosystems(Kim and Cho, 1991; Chang and Oh, 1995). Chang and Ahn(1995) reported that removal rate of inorganic constituents of the litters of *Pharagmites longivalvis* grassland in a delta of the Nakdong River.

Most of the sulphur which presents in plants comes from sulphate acquired from the soil by plant roots. However, sulphur can also be absorbed by leaves through stomates as gaseous sulfur dioxide, an environmental pollutant released from burning coal and wood (Dassler and Boritz, 1988; Chang *et al.*, 1993). Kim and Cho(1991) studied the improvement of water quality by aquatic macrophytes. Under the assumption that the grassland has the steady sate, Chang *et al.*(1995 a, b, c) investigated the energy flow and mineral cycles in the grassland ecosystem and aquatic plant ecosystem, but not sulphur in the aquatic grassland ecosystem.

It was the intent of this study to investigate the removal rate of sulphur of the litter in *Phragmites communis, Scirpus tabernaemontani, Miscanthus sacchariflorus* and *Typha angustata* on the lake Paldangho, the aquatic grassland ecosystem.

MATERIALS AND METHOD

The soil samples were collected by quadrat method from L, F, H and A_1 horisons in the *Phragmites communis, Scirpus tabernaemontani, Miscanthus sacchariflorus* and *Typha angustata* grasslands on the lake Paldangho in April, 1996. These were taken from the boxes, air-dried, and weighed. The litter productions were calculated on a dry weight basis.

Two grams of litter were heated at 450℃ for 24 hours. After ashing the litter, total sulphur was analyzed by the methods of Allen *et al.*(1974). The extracted solution was measured at 470nm wavelength for sulphur with the spectrophotometer.

RESULTS AND DISCUSSION

The geographical distribution of four plants is the order of *P. communis, S. tabernaemontani, M. sacchariflorus* and *T. angustata* from the outside of littoral zone to the inner side of littoral zone in the lake. The decomposition, accumulation and removal rate of sulphur on the grassland floor were estimated by the mathematical model.

1. Annual productions and removal rates of sulphur in the aquatic grasslands

Annual production of the sulphur in the grass-litters of the *P. communis, S. tabernaemontani, M. sacchariflorus* and *T. angastata* grasslands are shown in Table 1; S_{ss} represents the constituents containing the layer F, H, A_1 horizons in the steady states. The litter productions were presented with a dry weight.

The total accumulation of sulphur for litters of the *P. communis, M. sacchariflorus, T. angastata,* and *S. tabernaemontani* were 59.245, 60.401, 325.000 and 221.676 g/m^2 and annual productions of those were 50.913, 25.869, 151.386 and 180.828 g/m^2 respectively.

Under the assumption that the grassland floor in the studied area may reach a steady state, one method of estimating the fraction r can be made from the ratio of the vertical and horizontal coordinates of each point in Fig. 1.

According to the study of Oohara *et al.*(1971a) and Chang *et al.*(1995), the removal constant, r, of sulphur in litters can also be estimated. When the accumulation of sulphur reaches the steady state condition(S_{ss}) in a grassland ecosystem, the rate of annual addition(L) may be equal to the rate of removal. And then, the removal constant r is represented by $r = L/S_{ss}$. According to the point of view for the litter of steady state level, another removal constant r' also can be estimated when S_{ss} has not included the value of annual production.

The estimates of removal constants, r and r', for each grassland are given by Table 2. As shown in Table 2, the values of r were different on the grass species of which the grassland is composed. The removal rates of sulphur for litters of the *P. communis, S. tabernaemontani, M. sacchariflorus* and *T. angustata* are 0.859, 0.816, 0.428 and 0.466, repectively. The values of r' are larger than r in each grassland ecosystem. Considering that the removal rate can not have the value more than one theoretically, the differences of the values at r and r' suggest that the well-timed sampling should be accomplished before studied area has the newly fallen leaves of the year.

Table 1. The values of litter production and contents of sulphur (grams per square meter) for each soil samples at the grassland ecosystem on the lake Paldangho

Grasslands	Horizon	Dry weight (g/m^2)	Total sulphur (%)	Total sulphur (g/m^2)
Phragmites communis	L	3,550.4	1.434	50.913
	S_{ss}	810.4	2.129	8.332
Miscanthus sacchariflorus	L	3,440.0	0.752	25.869
	S_{ss}	2,728.9	2.413	34.532
Typha angustata	L	8,308.8	1.822	151.386
	S_{ss}	7,557.6	3.787	173.614
Scirpus tabernaemontani	L	6,136.0	2.947	180.828
	S_{ss}	3,111.2	2.749	40.848

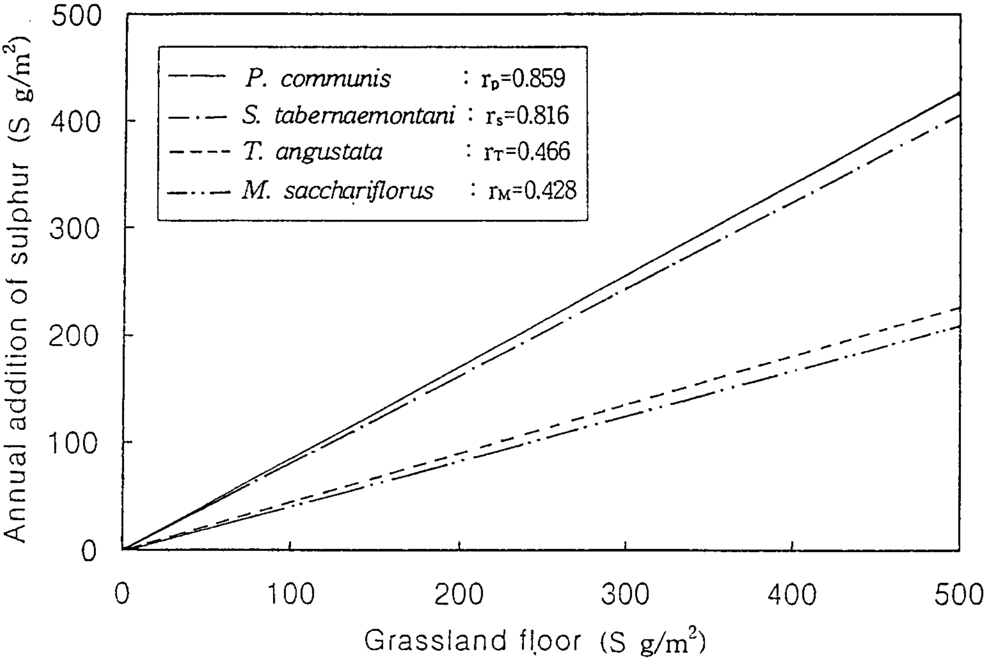

Fig. 1. The estimation of the removal constant *r* for sulphur in the four grasslands on the lake Paldangho.

It is considered that the higher removal constant is, the more rapidly constituents of litters return to the soil. Since the removal constant *r* of *P. communi* is the highest value, it can be considered that sulphur of litters *P. communis* among four grasslands is the most rapidly returned to the soil. And the value of removal constant of sulphur was also higher in *S. tabernaemontani* than in *M. sacchariflorus* and *T. angastata*.

Although it is necessary to study whether there is any significant relationship between the geographical distribution of plants on the lake and the removal rate, the removal of sulphur was faster in the grasslands, *P. communis* and *S. tabernaemontani*, at outside of littoral zone than in the innerside grasslands such as *M. sacchariflorus* and *T. angustata*.

Table 2. The constant for removal and exponential decomposition of sulphur in aquatic grassland ecosystems on the lake Paldangho

Grasslands	Removal constants		$t_{0.50}$ (years)	$t_{0.95}$ (years)	$t_{0.99}$ (years)
	r	r'	$0.693/r$	$3/r$	$5/r$
Phragmites communis	0.859	6.110	0.806	3.491	5.818
Miscanthus sacchariflorus	0.428	0.749	1.618	7.005	11.674
Typha angustata	0.466	0.872	1.488	6.440	10.734
Scirpus tabernaemontani	0.816	4.427	0.850	3.678	6.129

2. Turnover and accumulation of sulphur in the aquatic grassland ecosystems

According to Chang and Ahn(1995), the accumulation model of sulphur on the grassland floor is also given as follows; $Sa = \frac{L_s}{r}(1-e^{-rt})$ where L_s express the amount of an annual addition for sulphur in the grassland ecosystem.

The removal models of inorganic matters under the grassland ecosystems of the steady state conditions can be defined as the basic concept of decomposition (Oohara *et al.*, 1971a).

In the case of aquatic plant ecosystem the removal model of inorganic matters such as sulphur can be presented as follows; $Sr = S_0e^{-rt}$ where S_0 is the weight of sulphur in the surface soil initially.

This equation gives the fraction remaining as a negative exponential function and permits the calculation of the time required to remove 50, 95 and 99% of an initial level. The times to reach half, 95% and 99% loss of sulphur in the four grasslands were presented at Table 2. Models for the removal and the accumulation of sulphur in four grasslands were presented at Table 3. The graphical expressions for these equations were represented at Fig. 2 for *P. communis* and *M. sacchariflorus*, at Fig. 3 for *S. tabernaemontani* and *T. angustata*.

The accumulation curves are the mirror images of the curves for removal loss. And these figures indicate that the time required to reach a steady state or the zero level for sulphur varied to each grassland.

The times required to remove 50% of initial sulphur in the *P. communis, S. tabernaemontani, M. sacchariflorus* and *T. angustata* are 0.806, 0.850, 1,618 and 1.488 years, respectively. This means that the higher removal constant of sulphur from the litters in the surface soil is, the more rapidly the sulphur is decomposed.

Considering the decay of the constituents of the litter, the removal velocity of sulphur in aquatic grasslands was faster than those of other inorganic constituents in the non-aquatic grassland ecosystems (Chang *et al.*, 1995a, b, c, d). Therefore, it is considered that the removal of sulphur in the aquatic grassland ecosystem was facilitated not only by decomposing organisms but also by other factors such as water flows and precipitations.

Table 3. Models for the removal and the accumulation of sulphur in four grasslands on the lake Paldangho

Grasslands	Removal model	Accumulation models
P. communis	$Sr = 59.245e^{-0.859t}$	$Sa = 59.245(1-e^{-0.859t})$
M. sacchariflorus	$Sr = 60.399e^{-0.428t}$	$Sa = 60.399(1-e^{-0.428t})$
T. angastata	$Sr = 324.999e^{-0.466t}$	$Sa = 324.999(1-e^{-0.466t})$
S. tabernaemontani	$Sr = 221.676e^{-0.816t}$	$Sa = 221.676(1-e^{-0.816t})$

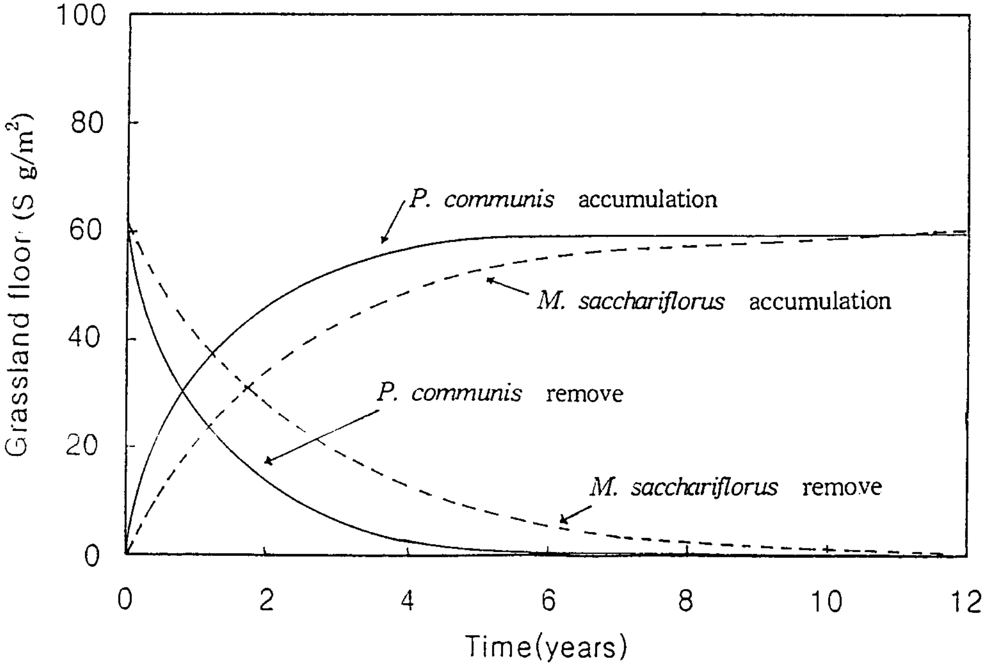

Fig. 2. The predictable illustration for the accumulation and the removal of sulphur in P. communis and *M. sacchariflorus* grasslands on the lake Paldangho.

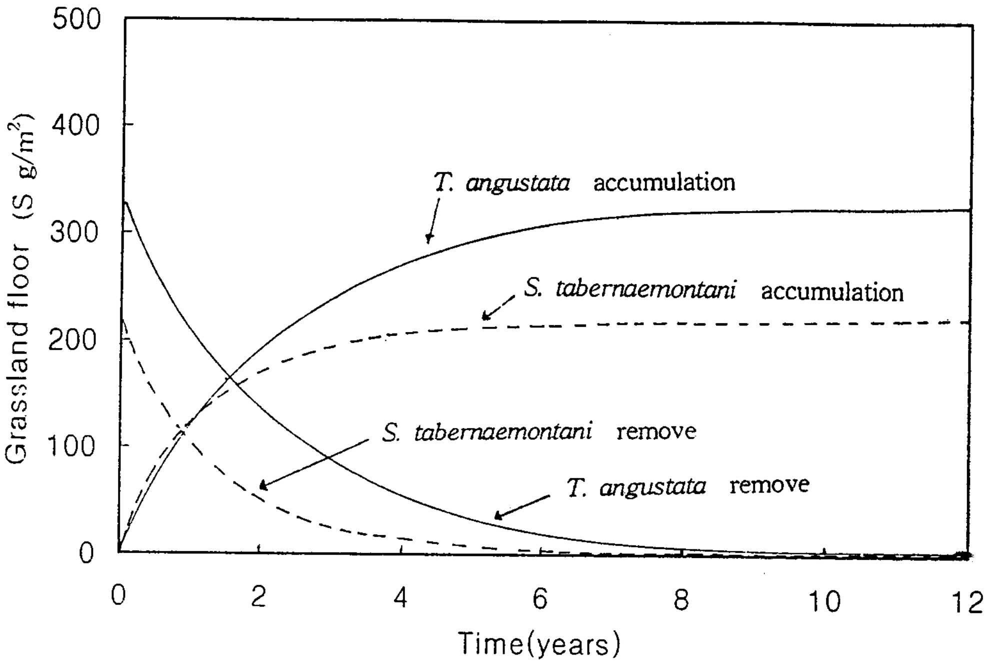

Fig. 3. The predictable illustration for the accumulation and the removal of sulphur in *T. angastata* and *S. tabernaemontani* grasslands on the lake Paldangho.

Kim and Chang (1967) reported that the decay rates of soil organic matter were accelerated with the increasing temperture. Oohara *et al.*(1971c) suggested that the decomposition of the litter, accumulated on the top of the mineral soil, involves leaching by snow or rain water and decay by light or heat. Chang and O (1995) suggested that the high decomposition and removal rate of hot water soluble fractions can be explained by the high temperature and much rainfall in summer. Since there is much rain usually during summer in Korea, it is considered that the high value of removal constant in the aquatic grasslands of the lake Paldangho ecosystem results from the water flow such as rainfalls.

Kim and Cho(1991) suggested that water quality in the lake Paldangho will be improved if the source of nutrients through macrophytes was cut off. However, considering the rapid cycle of sulphur, it is not absolutely necessary to weed out the aquatic macrophytes. As shown at this study, the high decay velocity of sulphur in four grasslands of aquatic ecosystem is meaningful to the rapid removal of sulphur, a pollutant, at the aquatic region. In other words, it is suggested that the efficient removal of pollutants from the lake can be accomplished by aquatic grasslands having a high removal constant r.

적 요

팔당호의 수생식물인 갈대, 고랭이, 억새, 부들 생태계에 있어서의 낙엽의 구성성분 중 황(S)의 유실률을 조사 연구하였다.

낙엽에 의한 황의 연생산량은 갈대 군락에서 50.91 g/m², 고랭이 군락에서 180.83 g/m², 억새 군락에서 25.87 g/m²이고 부들 군락에서는 151.39 g/m² 이었다.

황의 유실률 r은 갈대 군락에서는 0.86, 고랭이 군락에서 0.82, 억새 군락에서 0.43이고 부들 군락에서 0.47이었다. 평형상태에서 50, 95, 99%로 황의 분해 및 축적에 소요되는 시간은 갈대 군락에서 0.81, 3.49, 5.82년이며 고랭이 군락에서는 0.85, 3.68, 6.13년이었다. 억새 군락에서는 1.62, 7.00, 11.67년이었으며 부들 군락에서는 1.49, 6.44, 10.73년으로 각각 나타났다.

수생 식물 군락의 높은 황 유실율은 팔당호에서 황과 같은 오염물질의 효율적인 제거에 기여하는 것으로 사려된다.

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