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The Energy Flow and Mineral Cycles in a *Zoysia japonica* and a *Miscanthus sinensis* Ecosystem on Mt. Kwanak
8. The Cycles of Sulphur

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관악산의 잔디와 억새 생태계에 있어서 에너지의 흐름과 무기물의 순환
8. 황의 순환

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ABSTRACT

This study was performed to find out the mineral cycles of sulphur in dynamic grassland ecosystems in a steady state condition at the northwest side on Mt. Kwanak. The experimental results may be summarized on the communities of a *Zoysia japonica* and a *Miscanthus sinensis* as follows.

As compared with some properties of the surface soils among two semi-natural grasslands, sulphur war greater quantity in a *Miscanthus sinensis* than in a *Zoysia japonica* on Mt. Kwanak .

For the case of steady production and release, the raion of annual mineral production to the amount accumulated on the top of mineral soil in a steady state provides the estimates of release constant k. The release constants on sulphur of the litter were 0.54 in a *Zoysia japonica* and 0.36 in a *Miscanthus sinensis* grassland. The half times of S required for the release or accumulation of the litter on the grassland were 1.28 years in a *Zoysia japonica* and 1.93 years in a *Miscanthus sinensis*.

The amounts of annual cycles for sulphur in the grassland ecosystem under the steady-state conditions were 20.65g /m^2 in a *Zoysia japonica* and 26.28g /m^2 in a *Miscanthus sinensis* grassland.

Key words: *Zoysia japonica*, *Miscanthus sinensis*, Mt. Kwanak, Sulphur, Mineral cycles.

INTRODUCTION

Sulphur is widely distributed in rocks, being present as metal sulphides in unweathered igneous types. Weathered material, particularly sedimentary rocks may contain significant amounts of sulphate. The greater proportion of soil sulphur is present in the organic form whose estimation is rarely carried out. Mineral sulphur in soils is normally sulphate but sulphide and sulphite may be present under reducing conditions. Precipitation may contribute a significant amount of sulphate to the soil solution, and this is of both maritime and industrial origin.

Both plant and animal proteins contain sulphur amino-acids and it is present in some lipids. Sulphur also forms an energy bond, and contributes to oxidation-reduction changes in the metabolism. The concentration ranges generally encountered are 0.04% to 0.2% in mineral soils, 0.03% to 0.4% in organic soils(peat), 100 to 500μg/g in soil extractions and 0.08% to 0.5% in plant material(Allen *et al.*, 1974)

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 mathmatical 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.

Most of sulphur which presents in plants comes from sulphate acquired from the soil by plant roots. However, sulphur can also be adsorbed by leaves through stomates as gaseous sulfur dioxide, an environmental pollutant released from burning coal and wood(Dassler and Voritz, 1988; Chang *et al.*, 1993).

It was the intent of this study to investigate the release rate of sulphur of the litter in a *Zoysia japonica* grassland and a *Miscanthus sinensis* grassland on the Mt. Kwanak.

MATERIALS AND METHODS

The studied area and the methods to prepare the litter samples of *Zoysia japonica* and *Miscanthus sinensis* for mineral components were analyzed by Chang *et al.* (1995) and measured according to the method of Allen *et al.* (1974). The litter samples were collected by the quadrat method from the L, F, H and A_1 horizons in a *Miscanthus sinensis* grassland and in a *Zoysia japonica* grassland on Mt. Kwanak. The litter production was calculated on a dry weight basis.

Sample preparation and turbidimetric method for sulphur concentration analysis was performed according to the methods of Allen *et al.* (1974). The extracted solutions was measured at 470nm wavelength for sulphur with the spectrophotometer.

RESULTS AND DISCUSSIONS

1. Characteristics of the soils and the estimates of release constant of sulphur

Sulphur contents of the surface soils for the grasslands of *Z. japonica* and *M. sinensis* were given in Table 1. Until now, many study has been performed about these ecosystems such as the standing crop and production structure(Chang *et al.*, 1995a), organic matter

Table 1. Release constants and the amount of total sulfur for the accumulation and the decomposition of litters from *Zoysia japonica* and *Miscanthus sinensis* grasslands on Mt. Kwanak

Grassland	Unit	L	F	H	A_l	κ
Zoysia japonica	g/m^2	20.65	8.92	2.97	6.06	0.54
Miscanthus sinensis	g/m^2	26.28	29.89	14.76	2.16	0.36

synthesis and decomposition balance(Chang *et al.*, 1995b) and the cycles of nitrogen (Chang *et al.*, 1995c), phosphorus(Chang *et al.*, 1995d), potassium(Chang *et al.*, 1995e), calcium, magnesium, sodium(Kim *et al.*, 1996), manganese and zinc(Kang *et al.*, 1995a).

The annual production of sulphur for litters of the *Z. japonica* grassland was 20.65 g/m^2 and that of *M. sinensis* was 26.28 g/m^2. Other detailed characteristics of the litter organic matters for each horizon of surface soils and each grass species was shown in other related papers. The contents of sulphur in each horizon is shown in Table 1.

Table 2 shows the amount of total sulphur from each part of *M. sinensis*. As compared with them, content of sulphur was higher in dead-stem than in other parts such as live-stem, live-leaves and dead leaves.

Under the assumption(Oohara *et al.*, 1971) that the grassland floors in the stands here selected may apporoximate a steady state, one method of estimating the release of loss constant κ for sulphur can be obtained from the ratio of the vertical and horizontal coordinates of each point on Fig. 1. The estimate of constants for the *Z. japonica* grassland

Table 2. The amount of total sulphur from *Miscanthus sinensis* grassland on Mt. Kwanak

	Live-stem	Live-leaves	Dead-stem	Dead-leaves	Total
Total S(g/m^2)	5.12	12.79	2.39	5.98	26.28
Distribution ratio	12.26	22.96	56.18	8.60	100.00

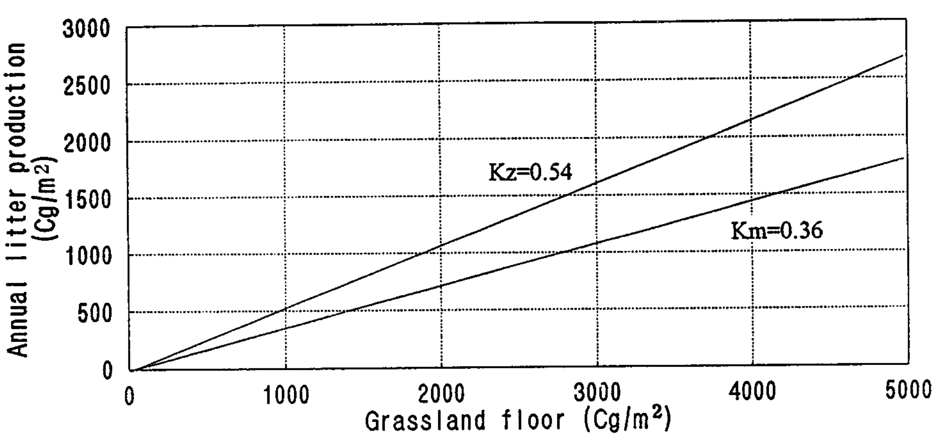


Fig. 1. Estimates of the release constants for S in a *Zoysia japonica* and a *Miscanthus sinensis* grassland from the ratio of annual addition of mineral components to the steady state accumulations.

Table 3. Release constants for exponential decomposition of total sulphur from a *Zoysia japonica* and a *Miscanthus sinensis* grasslands on Mt. Kwanak

Grassland	Loss constant $1/\kappa$	Half-time $0.693/\kappa$	95% time $3/\kappa$	99% time $5/\kappa$
Zoysia japonica	1.85	1.28	5.55	9.25
Miscanthus sinensis	2.78	1.93	8.34	13.90

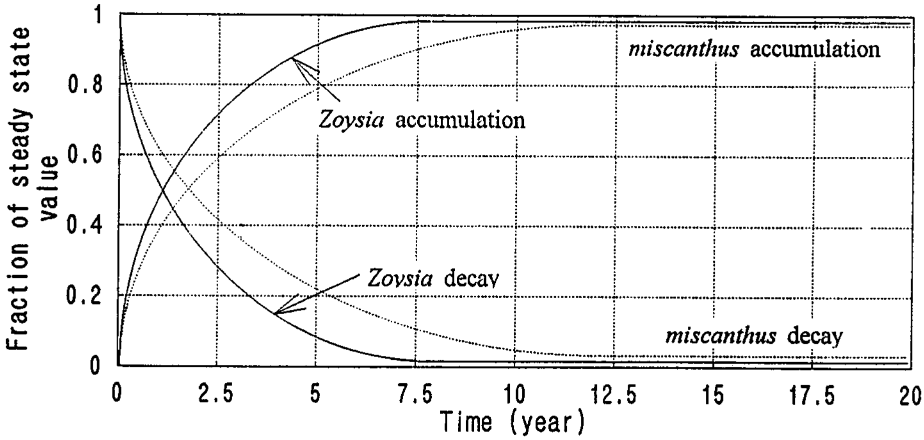


Fig. 2. Relation between the accumulation and decomposition on S from the litters of a *Zoysia japonica* and a *Miscanthus sinensis* grassland on Mt. Kwanak.

M. sinensis grassland are given by Table 1. As compared with each grassland, that of κ had a high value in the *Z. japonica* grassland, while being low in *M. sinensis* grassland. From this result it seems reasonable to suggest that the chemical composition of the grass-litter and its annual addition to the mineral soil in a semi-natural grassland ecosystem are different on account of the grass species of which the grassland is compared.

The release constant of the litter of *Z. japonica* grassland and *M. sinensis* grassland were 0.54 and 0.36, respectively. The periods required to release 50, 90, 95% fo sulphur were 1.28, 5.55, 9.25 years in the *Z. japonica* grassland and 1.93, 8.34, 13.90 years in the *M. sinensis* grassland, respectively. Decomposition rate of sulphur in the *Z. japonica* grassland was higher than in the *M. sinensis* grassland. Fig. 2 shows relation between the accumulation and decomposition on sulphur from the litters of a *Z. japonica* and a *M. sinensis* grassland on Mt. Kwanak.

2. The cycles of sulphur

Since the release constants of sulphur for grass-litters have been determined, the release models of potassium under the grassland ecosystems of the steady state conditions can be defined as the basic concept of decomposition(Oohara *et al.*) ; in the case of sulphur

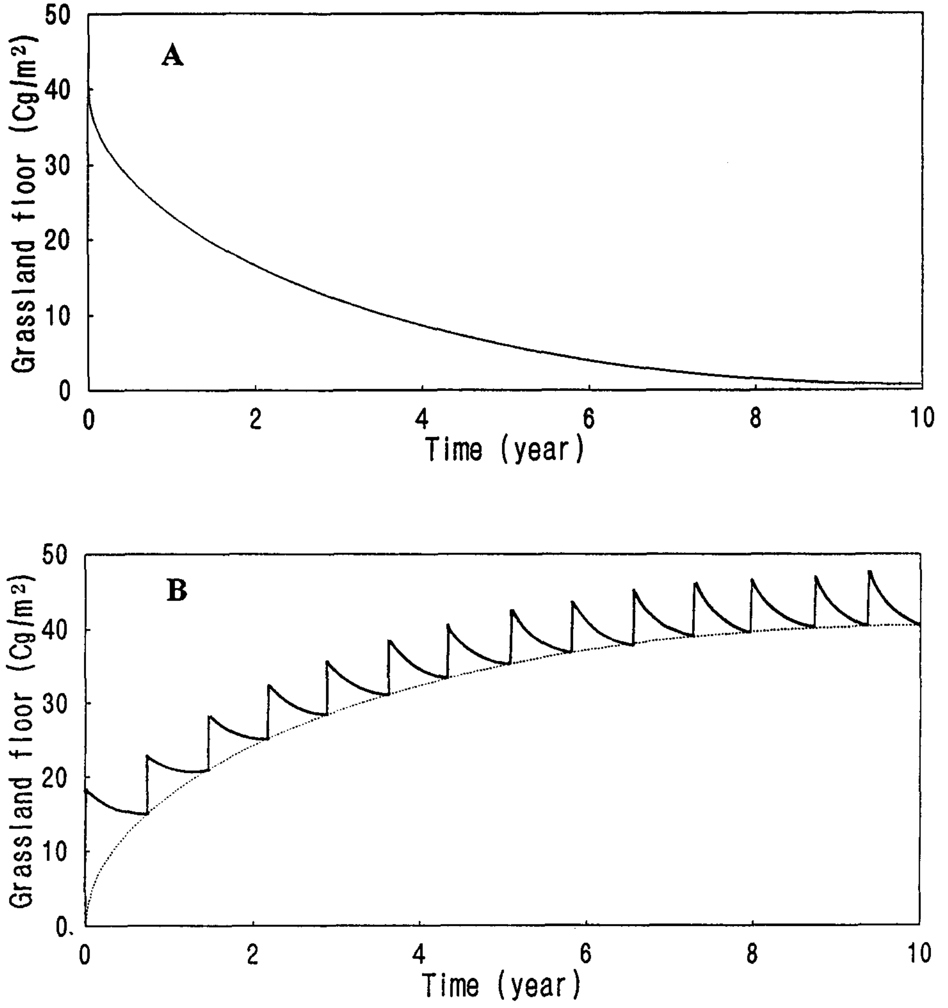


Fig. 3. A. Exponential curves for the release of sulphur of grass-litters under the *Zoysia japonica* grassland ecosystems on Mt. Kwanak.

B. The annual S cycle and accumulation of grass-litters in the *Zoysia japonica* grassland ecosystems on Mt. Kwanak.

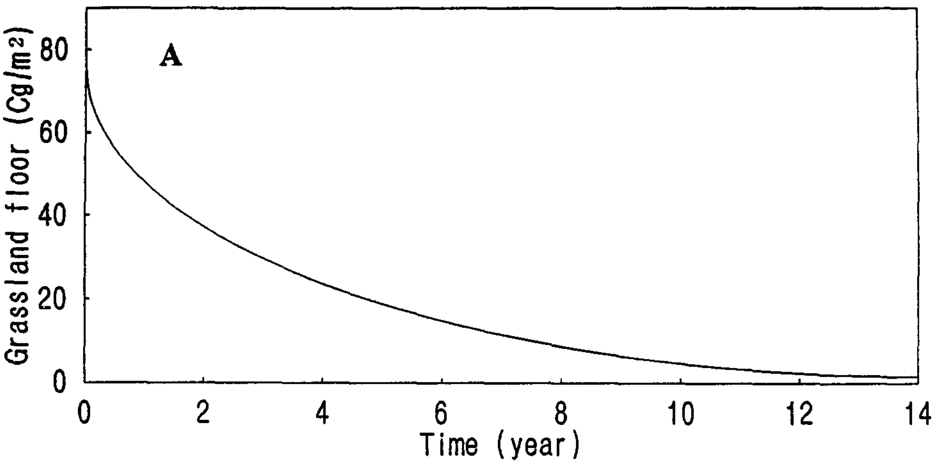
$$S = S_0 e^{-kt} \quad (1)$$

where S_0 is the weights of sulphur in the surface soil initially.

In *Zoysia japonica* grasslands,

$$S = 20.65e^{-0.54t} \quad (2)$$

In *Miscanthus sinensis* grasslands



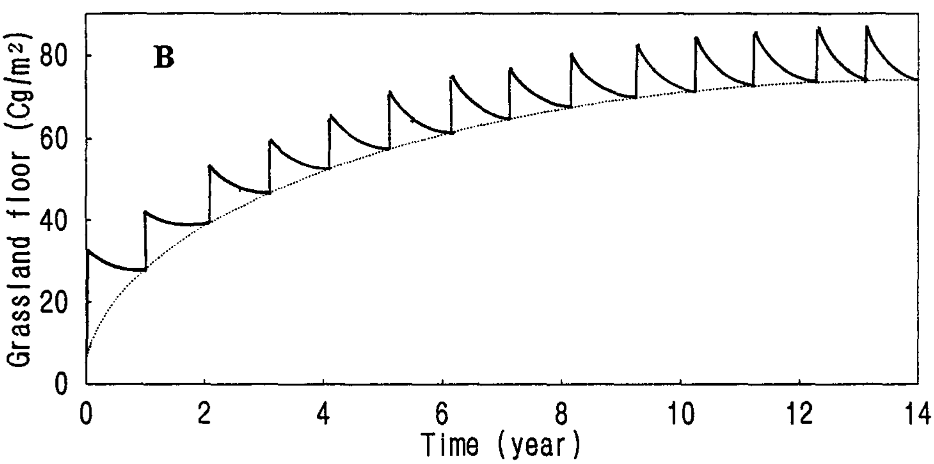


Fig. 4. A. Exponential curves for the release of sulphur of grass-litters under the *Miscanthus sinensis* grassland ecosystems on Mt. Kwanak.

B. The annual S cycle and accumulation of grass-litters in the *Miscanthus sinensis* grassland ecosystems on Mt. Kwanak.

$$S = 26.28e^{-0.36t} \tag{3}$$

Fig. 3 and Fig. 4 show the exponential curves of these models. The accumulation model of sulphur on the grassland floor is also given as follows;

$$Sa = \frac{S_k}{k}(1 - e^{-kt}) \tag{4}$$

where S_k expresses the amount of an annual addition for sulphur. This graphical curve is geven as the mirror image of the curve for the release.

In *Zoysia japonica* grasslands,

$$Sa = \frac{20.65}{0.54}(1 - e^{-0.54t}) \tag{5}$$

In *Miscanthus sinensis* grasslands

$$Sa = \frac{26.28}{0.36}(1 - e^{-0.36t}) \tag{6}$$

Fig. 3 and Fig. 4 show the exponential curves of these accumulation model for sulphur in the two grasslands ecosystem.

적 요

본 연구는 관악산의 북서면에 위치하는 잔디와 억새 초지에서 이루어지고 있는 황의 순환 작용을 규명하고자 조사 비교한 것으로 그 결과는 다음과 같다.

두 개의 초지 군락에서 표면층의 토양을 비교해 보면 잔디 군락(20.65g/m^2)에 비해 억새 군락에서의 황의 함량이 26.28g/m^2로 더 높음을 알 수 있었다. 잔디 군락에서 황의 release constant는 0.54였으며, 억새 군락에서는 0.36이었다.

평형상태에서 50, 90, 95%로 분해 및 축적되는데 걸리는 시간은 각각 0.693/k, 3/k, 5/k년이므로, 본 연구를 통하여 관악산의 초지 생태계에서 황이 50, 90, 95%로 분해 및 축적되는데 걸리는 시간은 잔디 군락에서는 1.28, 5.55, 9.25년이었고, 억새 군락에서는 1.93, 8.34, 13.90년이었다.

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