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The Energy Flow and Mineral Cycles in a *Zoysia japonica* and a *Miscanthus sinensis* Ecosystem on Mt. Kwanak 11. The Cycles of Al

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관악산의 잔디와 억새 생태계에 있어서 에너지의 흐름과 무기물의 순환 11. 알루미늄의 순환

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ABSTRACT

The investigation was cycle of aluminum of surface soil elements in dynamic grassland ecosystems at a steady state in a *Zoysia japonica* and a *Miscanthus sinensis* ecosystem in Mt. Kwanak, Korea. Average amounts of total storage for aluminum in *Z. japonica* and *M. sinensis* grasslands were 8,426mg/m^2 and 7,849mg/m^2 respectively. Decay constants estimated on the base of experimental and mathematical model, were 0.04 in *Z. japonica* grassland, and 0.08 in *M. sinensis* grassland. Half time to decay aluminum of litter soils were 17.33 years in *Z. japonica* grassland, and 8.66 years in *M. sinensis* grassland. 95% decay times in *Z. japonica*, and in *M. sinensis* grassland were 75.0 years and 35.0 years respectively. Needed times to lose almost all of elements in *Z. japonica* and *M. sinensis* grassland were 125.0 years, and 62.50 years respectively. The metals were losed more rapidly in *M. sinensis* than in *Z. japonica* grassland. The cycle of aluminum was investigated to be related with soil acidity.

Key words: Cycle of aluminum, *Zoysia japonica, Miscanthus sinensis,* Mt. Kwanak, Decay constants, Soil acidity.

INTRODUCTION

Decomposition of mineral elements is influcenced by climatic conditions, physical properties, and chemical characteristics of soil and minerals. Major natural sources of micronutrients are oxides, silicates, carbonates and sulfides. Macronutrients change affect the mineral forms of micronutrients. The micronutrients cations released as weathering occurs are subject to colloidal adsorption. Aluminum is soluble and exchangeable with other cations in very acidic soils, and either tightly bound by organic matter or present in the form of aluminum or aluminum hydroxy cations (Brady, 1990). Hydrated aluminum influences the pH of soils.

In plant ecosystems, accumulation and decomposition of mineral elements of litter have affected productivity and soil properties (Chang *et al.*, 1987b). Since Jenny *et al.* (1949) suggested mathematical model on the accumulation and decomposition of organic carbon by litter production, Olson (1963), Oohara *et al.* (1971), Chang and Yoshida (1973), Chang *et al.* (1987a, b, 1995a, b) and Kim and Chang (1996) suggested the accumulation and annual cycles of mineral elements by litter production and decomposition, and decay and turnover of them on the base of experimental and mathematical model in the grassland ecosystems. The decay and turnover were reported in a *Sasa* grassland (Chang and Yoshida, 1973), *Zoysia* and *Miscanthus* grassland (Kim and Chang, 1996; Chang *et al.*, 1995a, b), a *Phragmites* grassland in the littoral zones (Chang and Ahn, 1995; Chang and Oh, 1995) and *Phragmites, Miscanthus, Scirpus* and *Typha* grasslands in the littoral zones of the lake Paldangho (Shim *et al.*, 1995; Park *et al.*, 1995). Chang *et al.* (1987a) estimated the parameters and times of mineral nutrients decomposition in *Quercus, Pinus, Carpinus, Robinia, Abies* and *Larix* forests, and *Phragmites* grassland, and suggested the decay map and turnover cycles of litters in Korea.

In steady state of grassland ecosystem, the net change rate in annual addition of elements into soil is equal to that of the annual removal. Present investigation is to elucidate decay constants of aluminum in litter soils, and estimates and compare the cycles of mineral components in the grasslands of *Zoysia japonica and Miscanthus sinensis* in terrestrial ecosystems in Mt. Kwanak.

MATERIALS AND METHODS

Samples to analyze were collected from surface soil layer in *Zoysia japonica* and *Miscanthus sinensis* in Mt. Kwanak, Seoul, Korea. They were obtained from L, F, H, and A_1 horizon by quadrat method. Scale of quadrats was 0.25 by 0.25 m. Biomass was calculated as weights of air-dried fractions. Aluminum were measured according to Allen's method (Allen *et al.*, 1974). Adding orderly 60% $HClO_4$ 1ml, conc. HNO_3 5ml and conc. H_2SO_4 0.5ml to 0.5g air-dryed sample in 100ml Kjeldahl flask and boil it, at low temperature to digest slowly for 12~15 mins, after then cooling at room temperature, and dilute to total 50ml solution with distilled water after filtering the cooled it with Whatmann No. 44. Quantify this extracts by atomic absorption spectrophotometry (model 303). Decay and accumulation of litters in grassland ecosystems, and decay constants were estimated on the based of experimental and theoretical models suggested by Chang and Yoshida (1973) and Chang *et al.* (1987a, b, 1995a, b).

RESULTS AND DISCUSSION

At a steady state in *Zoysia japonica* and *Miscanthus sinensis* grassland ecosystems in Mt. Kwanak, Korea, the annual production, accumulation and decay, and cycle of aluminum was investigated. Total amounts of aluminum collected from surface soil such as litter, fermentation, humus and A_1 layers, were shown in Table 1. And the parameters of accumulation and decompostion, and decay half time and times needed to decay 95 % and 99 % of initial amounts were shown in Table 2. Total average storage of aluminum in *Z. japonica,* and in *M. sinensis* grasslands were 8,426 mg /m^2 and 7,849 mg /m^2 respectively. Inputs of litters of *Z. japonica* were more than those of litters of *M. sinensis.*

In a steady state with accumulation and decomposition, the quantitative annual cycles of them in grassland ecosystems can be estimated by content amounts of surface soil profiles on the base of experimental and mathematical model (Chang and Yoshida, 1973; Chang *et al.*, 1987a, b; Chang *et al.*, 1995a, b). Mineral nutrients in litter layers may be accumulated and decomposed with successive serial stages. Decay constants were aluminum 0.04 of *Z. japonica* grassland, and 0.08 of *M. sinensis* grassland (Fig. 1). Half times of aluminum decay were 17.33 years in *Z. japonica* and 8.66 years in *M. sinensis.* 95% loss time of initial amounts were 75.00 years in *Z. japonica,* and 37.50 years in *M. sinensis.* Needed times to decay almost all of elements in *Z. japonica* and *M. sinensis,* were 125.0 years, and 62.50 years respectively. Aluminum was decayed more rapidly in *M. sinensis* than in *Z. japonica* (Fig. 2~3).

The cascade of trace heavy metals, aluminum, flowed in *M. sinensis* grassland in Mt.

Table 1. The amounts of aluminum of surface soil profiles from *Zoysia japonica* and *Miscanthus sinensis* grassland ecosystems in Mt. Kwanak

Horizon	*Zoysia japonica* (g /m^2)	*Miscanthus sinensis* (g /m^2)
L	0.367	0.650
F	0.501	1.841
H	0.540	2.494
A_1	7.018	2.863

Table 2. Parameters of decay of aluminum of litters from *Zoysia japonica* and *Miscanthus sinensis* grassland ecosystems in Mt. Kwanak

Parameter	*Zoysia japonica*	*Miscanthus sinensis*
k	0.04	0.08
1 /k	25.00	12.50
$t_{.50}$ (years)	17.33	8.66
$t_{.95}$ (years)	75.00	37.50
$t_{.99}$ (years)	125.00	62.50

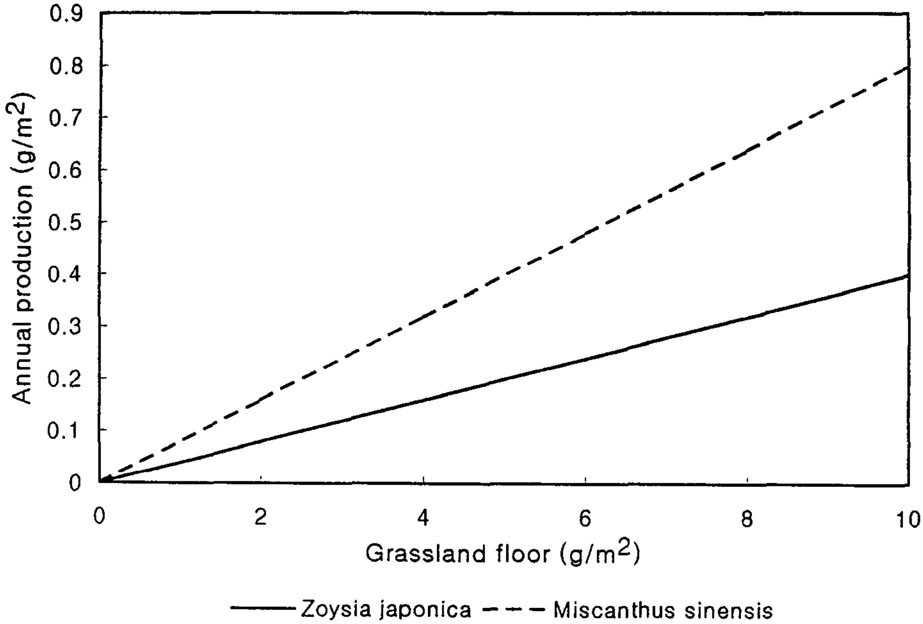

Fig. 1. Estimates of decay constants for aluminum in *Zoysia japonica* and *Miscanthus sinensis* at steady state grassland floor in Mt. Kwanak.

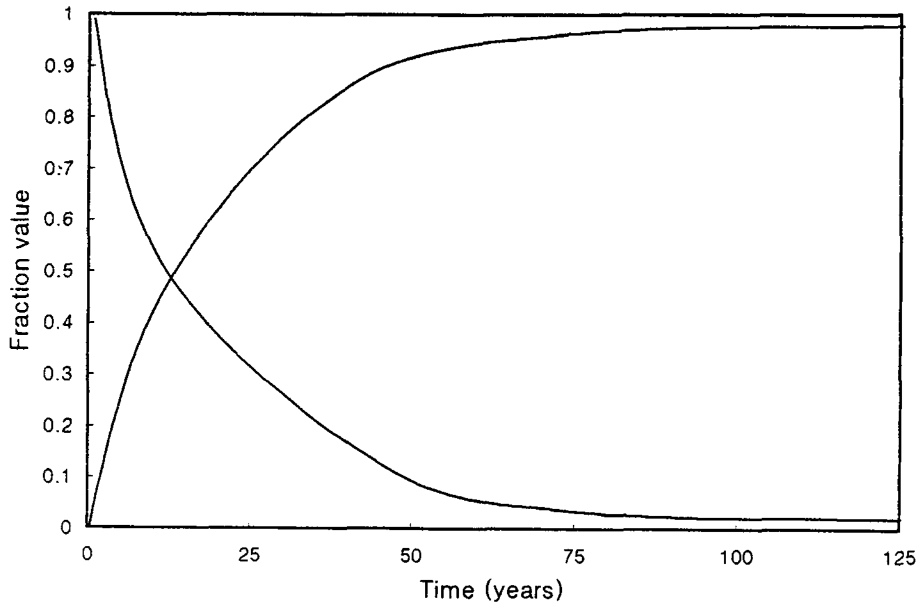

Fig. 2. Relation between the accumulation and decomposition of aluminum from litters of *Zoysia japonica* at steady state grassland floor in Mt. Kwanak.

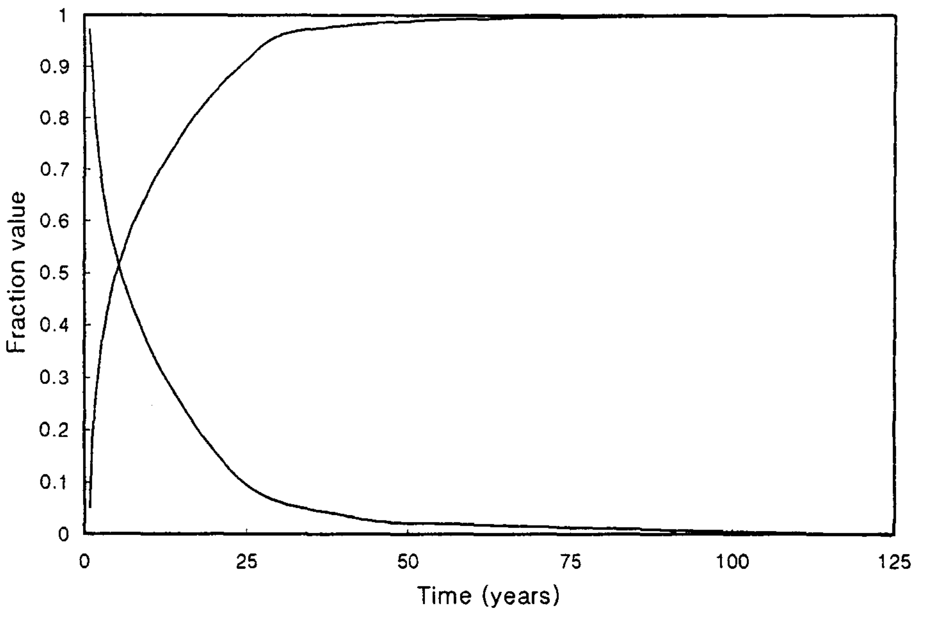

Fig. 3. Relation between the accumulation and decomposition of aluminum from litters of *Miscanthus sinensis* at steady state grassland floor in Mt. Kwanak.

Table 3. The amounts of aluminum from *Miscanthus sinensis* grassland ecosystems in Mt. Kwanak

Fractions	Al(g /m²)	Fractions(%)
Live-stem	0.188	28.95
Dead-stem	0.076	11.73
Live-leaves	0.275	42.21
Dead-leaves	0.111	17.11
Total	0.650	100.00

Kwanak was shown in Table 3. The live-componets as well as dead-components influenced on cycling and releasing mineral elements.

The soil acidity significantly affects the availability of most of the chemical elements of importance to plants and microbes. Table 4 shows soil acidity of litter, fermentation, humus and A_1 layers of *Zoysia japonica* and *Miscanthus sinensis* grassland ecosystems. Soil acidity in *Miscanthus sinensis* grassland was higher than that in *Zoysia japonica* grassland. Under very acid soil condition such as pH less than 5.0, much aluminum becomes soluble and is tightly bound by organic matter or is present in the form of aluminum or aluminum hydroxy actions. Moderately acid soil with pH values between 5.0~6.5, have somewhat higher percentage base saturations and aluminum can no longer exist as ions but is converted to aluminum hydoxy ions (Brady, 1990). Soil pH of *Miscanthus* grassland in Mt. Kwanak was 4.57~5.70 and that of *Zoysia* grassland was 5.02~6.00. Aluminum was ex-

Table 4. Acidity (pH) of surface soils in *Zoysia japonica* and *Miscanthus sinensis* grasslands in Mt. Kwanak

Horizon	*Zoysia japonica*	*Miscanthus sinensis*
L	6.00	5.70
F	5.02	4.89
H	5.43	4.57
A_1	5.74	5.50

changeable and available in the soils of *Miscanthus* grassland in Mt. Kwanak.

적 요

평형 상태에 도달하여 있는 관악산의 잔디 (*Zoysia japonica*)와 억새 (*Miscanthus sinensis*) 초지 생태계에서 중금속 알루미늄 (Al)의 순환에 대해서 조사하였다. 토양 내 평균 저장량은 잔디와 억새 군락에서 각각 8,426 mg/m²과 7,849 mg/m²이었다. 실험적 · 수학적 모델을 기초로 하여 산출한 분해상수는 잔디 군락에서는 0.04이었으며, 억새 군락에서는 0.08이었다. 알루미늄의 초기 함량에 대한 반감기는 잔디 군락에서 17.33년, 억새군락에서 8.66년으로 조사되었다. 95% 및 99% 분해하는데 소요되는 시간은 잔디 군락에서 각각 75.0년 및 125.0년이었으며, 억새 군락에서는 35년 및 62.5년으로 나타났다. 토양의 표층내에 있는 구성 성분의 분해 속도는 잔디에서 보다 억새 군락에서 더욱 빠르게 나타났다. 토양 산성도가 알루미늄의 순환에 영향을 미치는 것으로 사료된다.

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