Kor. Turfgrass Sci., 11(4), 289~294, 1997

The Energy Flow and Mineral Cycles in a *Zoysia japonica* and a *Miscanthus sinensis* Ecosystem on Mt. Kwanak 9. The Cycles of Hg, Pb and Cd

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관악산의 잔디와 억새 생태계에 있어서 에너지의 흐름과 무기물의 순환 9. Hg, Pb와 Cd의 순환

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ABSTRACT

The cycles of heavy metals, mercury, lead and cadmium, were investigated on in dynamic grassland ecosystems at a steady state in *Zoysia japonica* and *Miscanthus sinensis* in Mt. Kwanak, Korea. Estimates of decay constants of heavy metals based on experimental and methomatical model, were Hg 0.14, Pb 0.17 and Cd 0.41 of *Z. japonica* grassland, and Hg 0.33, Pb 0.13 and Cd 0. 56 of *M. sinensis* grassland. The durations of reaching half of initial amounts in *Z. japonica* and *M. sinensis* grassland, were Hg 4.95, Pb 4.07 and Cd 1.69 years, and Hg 2.10, Pb 5.33 and Cd 1.24 years respectively. Times needed for 99% decomposed were longer in *Z. japonica* than *M. sinensis* grassland. Decay velocity of constituents of surface soil layers were more rapidly in *M. sinensis* than *Z. japonica* grassland.

Key words: Cycles of heavy metals, Mercury, Lead, Cadmium, *Zoysia japonica, Miscanthus sinensis,* Mt. Kwanak, Decay constants.

INTRODUCTION

Many heavy metals are toxic to plants or animals if absorbed in exececssive amounts. Trace of mercury, cadmium, and lead are present in most soils but their minerals are relatively rare. They are significant as environmental pollutants as well as industrial wastes, agricultural pesticides and the product of human activities. Generally, most toxic heavy metals are present in environment as cations or inorganic chelates. Large proportion of the analytical results obtained from various biomaterials are mainly intended to demonstrate the powerful capabilities of the newly emerging study (Markert and Thornton, 1990).

Inputs and outputs of constituents are small in comparison with the amounts held in biomass and recycled within the system (Lindberg *et al.*, 1986). Oohara *et al.* (1971) and Chang *et al.* (1995a, b) suggested the role of mineralization, accumulation and annual cycles of mineral elements in the grassland ecosystems. Olson (1963) quantified mathematically accumualtion in plant communities on the base of input and output of litters. In addition, he suggested the methods to determine the decay constant. Chang and Yoshida (1973), Kim and Chang (1996) and Chang *et al.* (1995a, b) reported the decay and turnover in the grassland and forest ecosystems. Chang and Ahn (1995) and Chang and Oh (1995) investigated the decay of the litters in a *Phragmites* grassland ecosystems, and Shim *et al.* (1995) and Park *et al.* (1995) reported the decay and accumulation of litters in the littoral zones of the lake Paldangho. They reported removal constants according to theoretical decay model. Choi *et al.* (1996) calculated removal rates of cadmium and lead of litters in the littoral grassland ecosystems in the lake Paldangho.

The soils play roles as large storage compartment in the ecosystems and as exchange sites of cations. Rainfall discharge maintains a constant chemical concentrations (Waring and Schlesinger, 1985). Present investigation is to determine decay rates of heavy metals of litters in soils, and estimates and compare the cycles of mineral components in the grasslands of *Zoysia japonica* and *Miscanthus sinensis* in terrestrial ecosystems.

MATERIALS AND METHODS

Litter samples were collected from *Zoysia japonica* and *Miscanthus sinensis* in Mt. Kwanak, Seoul, Korea. They were obtained from L, F, H, and A1 horizon by quadrat method. Scale of quadrats was 0.25 by 0.25 m. Biomass was calculated as weights of air-dried fractions. Heavy metals, mercury, lead and cadmium, were measured according to Allen's method (Allen *et al.*, 1974). Mercury, lead and cadmium were extracted from litter layers by boiling a 1ml Kjeldahl flask including adding orderly 60% $HClO_4$ 1ml, conc. HNO_3 5ml and conc. H_2SO_4 0.5ml to 0.5g air-dryed sample 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. Each traces of these extracts were determined by atomic apsortion spectrophotometry (model 303). Production, 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.* (1995a, b).

RESULTS AND DISCUSSION

It was investigated for annual production and decay of constituents of litters of *Zoysia* *japonica* and *Miscanthus sinensis* grassland ecosystems in Mt. Kwanak. Amounts of heavy metals such as mercury, lead and cadmium, from surface soil profiles and half time, 95% decay time and 99% decay time were shown in Table 1 and 2. The average amounts of the total storage of heavy metals were Hg 9.532 mg/m², Pb 69.12 mg/m² and Cd 59.38 mg/m² in *Z. japonica*, and Hg 11.788 mg/m², Pb 230.88 mg/m² and Cd 169.49 mg/m² in *M. sinensis*. Content amounts of heavy metals were related to traffic currents and characteristics of soils (Chang *et al.*, 1990). Inputs of litters of *Z. japonica* were not more than those of litters of *M. sinensis*. As this, more mercury, lead and cadmium were added to soil surface in *M. sinensis* grassland.

Chemicals may be accumulated and decomposed with successive serial stages. 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 based on experimental methodology. At a steady state level, decay rates of constituents were calculated by mathematical model (Chang and Yoshida, 1973). Decay constants were Hg 0.14, Pb 0.17 and Cd 0.41 of *Z. japonica* grassland, and Hg 0.33, Pb 0.13 and Cd 0.56 of *M. sinensis* grassland (Fig. 1~2). Half time of Hg, Pb and Cd, were 4.95, 4.07 and 1.69 years

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

Grassland	Horizon	Hg(mg/m²)	Pb(mg/m²)	Cd(mg/m²)
Zoysia japonica	L	1.323	11.76	24.48
	F	0.740	15.79	15.86
	H	0.431	9.34	8.25
	A1	7.038	32.23	10.79
Miscanthus sinensis	L	3.944	29.44	95.44
	F	3.025	122.06	46.48
	H	2.159	77.74	23.37
	A1	2.660	1.64	4.20

Table 2. Parameters of decay of Hg, Pb and Cd of litters from *Zoysia japonica* and *Miscanthus sinensis* grassland ecosystems in Mt. Kwanak

Grassland	Parameter	Hg	Pb	Cd
Zoysia japonica	k	0.14	0.17	0.41
	1/k	7.14	5.88	2.44
	$t_{.50}$ (years)	4.95	4.07	1.69
	$t_{.95}$ (years)	21.42	17.64	7.32
	$t_{.99}$ (years)	35.70	29.40	12.20
Miscanthus sinensis	k	0.33	0.13	0.56
	1/k	3.03	7.69	1.79
	$t_{.50}$ (years)	2.10	5.33	1.24
	$t_{.95}$ (years)	9.09	23.07	5.37
	$t_{.99}$ (years)	15.15	38.45	8.95

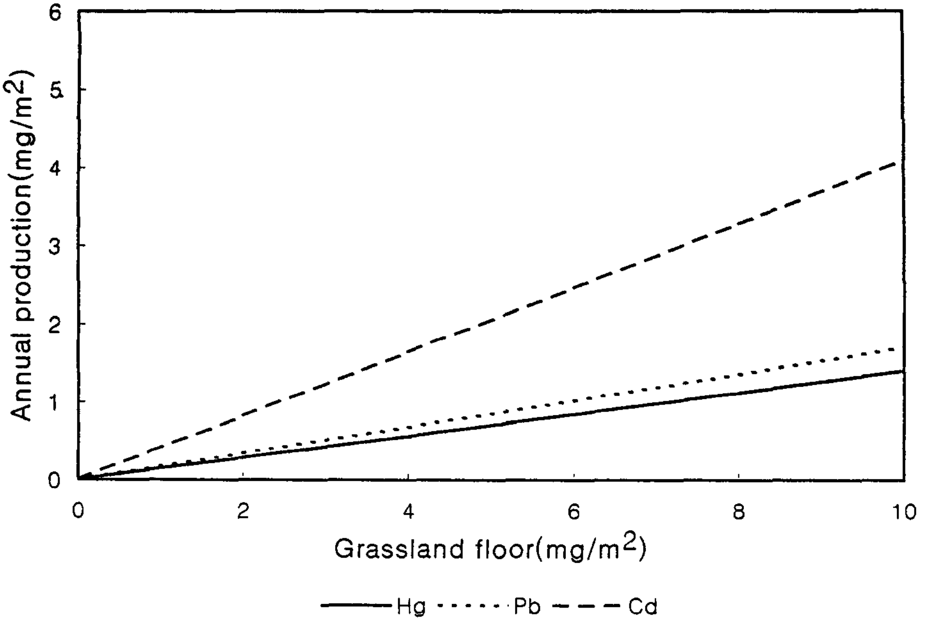

Fig. 1. Estimates of decay constants for heavy metals, Hg, Pb and Cd in *Zoysia japonica* at steady state grassland floor in Mt. Kwanak.

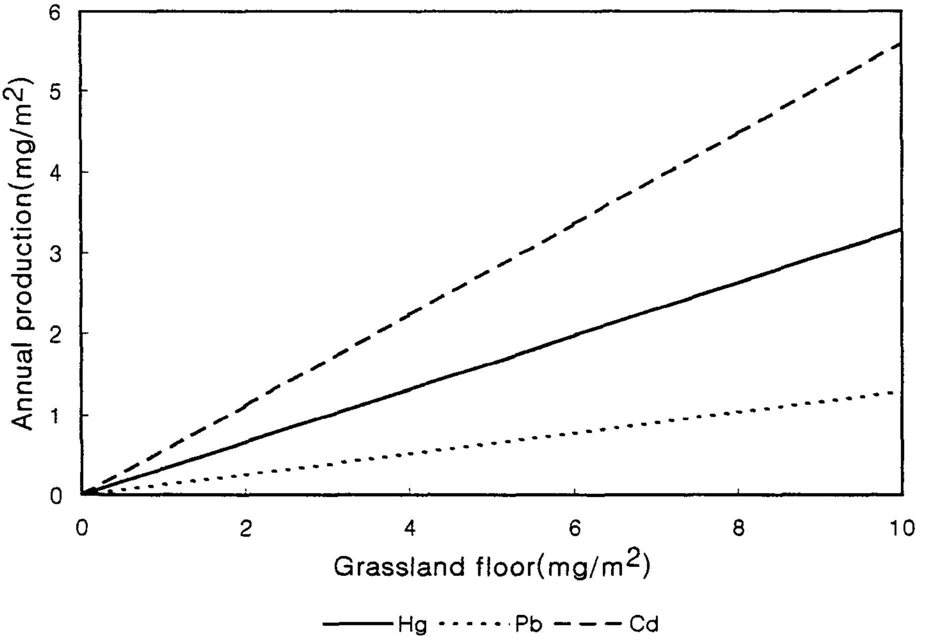

Fig. 2. Estimates of decay constants for heavy metals, Hg, Pb and Cd in *Miscanthus sinensis* at steady state grassland floor in Mt. Kwanak.

Table 3. The amounts of Hg, Pb and Cd from *Miscanthus sinensis* grassland ecosystems in Mt. Kwanak

Grassland	Fractions	Hg(mg/m²)	Pb(mg/m²)	Cd(mg/m²)
Miscanthus sinensis	Live-stem	0.888(22.52%)	4.579(15.56%)	22.96(24.06%)
	Dead-stem	0.022(0.56%)	6.266(21.29%)	13.61(14.26%)
	Live-leaves	2.959(75.02%)	7.849(26.66%)	36.96(38.72%)
	Dead-leaves	0.075(1.90%)	10.741(36.49%)	21.91(22.96%)
Total		3.944(100.0%)	29.435(100.0%)	95.44(100.0%)

repectively in *Z. japonica* and 2.10, 5.33 and 1.24 years respectively in *M. sinensis*. 95% decay time were Hg 21.42, Pb 17.64 and Cd 7.32 years in *Z. japonica* and Hg 9.09, Pb 23.07 and Cd 5.37 years in *M. sinensis*. Almost all decay of constituents in *Z. japonica* and *M. sinensis*, needed Hg 35.70 and 15.15, Pb 29.40 and 38.45, Cd 12.20 and 8.95 years respectively. The heavy metals were losed more rapidly in *M. sinensis* than in *Z. japonica*. For there were more leaching and litter decomposition by microbes in *M. sinensis* grassland. But for lead in *M. sinensis*, decay constant was smaller than in *Z. japonica*.

The estimates of decay constants in mountain grasslands were smaller than those of removal constants in littoral grasslands (Chang and Oh, 1995; Choi *et al.*, 1996; Shim *et al.*, 1996). However, for cadmium, decay constant in this study area was almost same as that in littoral zones (Choi *et al.*, 1996). More times to reach half loss, 95% loss and 99% loss of heavy metals were needed in mountain grasslands. Causes of that are following by water currents and leaching velocity (Shim *et al.*, 1996).

As shown in Table 3, the cascade of heavy metal traces flowed in *M. sinensis* grassland in Mt. Kwanak. The live-components, stem and leaves, influenced on cycling and releasing mineral elements. But for Pb, dead parts included more amounts of minerals.

적 요

관악산의 잔디 (*Zoysia japonica*)와 억새 (*Miscanthus sinensis*) 초지 생태계에서 중금속 수은 (Hg), 납 (Pb) 및 카드뮴 (Cd)의 순환에 대해서 조사하였다. 수학적 이론적 모델을 기초로 하여 산출한 중금속 분해 상수는 잔디 군락에서는 Hg 0.14, Pb 0.17 및 Cd 0.41이었으며, 억새 군락에서는 Hg 0.33, Pb 0.13 and Cd 0.56이었다. 중금속의 초기 함량에 대한 반감기는 잔디의 Hg 4.95, Pb 4.07, Cd 1.69년 및 억새의 Hg 2.10, Pb 5.33, Cd 1.24년으로 조사되었다. 99% 분해하는데 소요되는 시간은 반감기와 마찬가지로 잔디 군락에서 길었으며, 토양의 표층내에 있는 구성성분의 분래 속도는 잔디에서 보다 억새 군락에서 더욱 빠르게 나타났다.

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