Kor. Turfgrass Sci., 11(4), 295~301, 1997

The Energy Flow and Mineral Cycles in a *Zoysia japonica* and a *Miscanthus sinensis* Ecosystem on Mt. Kwanak 10. The Cycles of Cu

Shim, Kew-Cheol, Sung-Hee Yau and Nam-Kee Chang

Department of Biology Education, Seoul National University

관악산의 잔디와 억새 생태계에 있어서 에너지의 흐름과 무기물의 순환 10. 구리의 순환

심규철 · 여성희 · 장남기

서울대학교 사범대학 생물교육과

ABSTRACT

The cycle of heavy metal, copper, was investigated in dynamic grassland ecosystems at a steady state in a *Zoysia japonica* and a *Miscanthus sinensis* ecosystem in Mt Kwanak, Korea. Total average storage amounts in *Z. japonica* and *M. sinensis* grasslands were copper 23.92mg /m^2 and 51.82mg /m^2 respectively. Estimates of decay constants for based on experimental and mathematical model, were 0.18 in *Z. japonica* grassland, and 0.30 in *M. sinensis* grassland. Decay half time of copper were 3.85 years in *Z. japonica* grassland and 2.31 years in *M. sinensis* grassland. 95% decay times of initial copper amounts in *Z. japonica* and *M. sinensis* were 16.68 and 9.99 years. Needed times to decay almost all of elements in *Z. japonica* and *M. sinensis* grassland were 27.80 years and 16.65 years respectively. The copper was losed more rapidly in *M. sinensis* than in *Z. japonica* grassland.

Key words: Cycle of heavy metal, Copper, *Zoysia japonica*, *Miscanthus sinensis*, Mt. Kwanak, Decay constants

INTRODUCTION

Heavy metal toxicity to plants was reviewed(Pahlsson, 1989). However, copper are essential micronutrients to plants and are involved in physiological and biochemical responses. A deficiency of copper causes changes in several important metabolic processes and growth of root, seedling and shoot of plants. Copper acts as a component of several

enzymes, nitorgen and cell wall metabolism, seed production and disease resistance (Pahlsson, 1981). As well, it plays an important role in photosynthesis, protein and carbohydrate metabolism, and probably nitrogen fixation(Brady, 1990). However, higher levels of copper is extremely toxic to plants. Deficiency of phosphorus in plant materials enhanced the toxicity of copper(Wallace, 1984). Copper is one of soil polluants, and contaminates soil as mine tailing, fly ash, fertilizers, and wind blon copper-containing dust.

Litter production is primarily effected on by wind, water content and current, geography and human, and is secondarily by input-output dynamics of litters(Ovington and Heitkamp, 1960). To investigate on energy flow and nutrients cycles, it was needed to use mathematical model. Accumulation and decomposition of mineral elements of littes 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) suggested the role of mineralization, accumulation and annual cycles of mineral elements, and decay and turnover 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). 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 of *Phragmites*, *Miscanthus*, *Scirpus* and *Typha* grassland in the littoral zones of the lake Paldangho. Yun *et al.*(1996) calculated removal rates of zinc, copper and iron of litters in the littoral grassland ecosystems in the lake Paldangho. Choi *et al.*(1996) calculated removal rates of cadmium and lead of litters in the littoral grassland ecosystems in the lake Paldangho. Chang *et al.*(1987a) suggested the decay map and turnover cycles of litters in Korea.

Cycles of heavy metals such as Pb, Cd, Fe, Cu and Zn of surface soil layers have been investigated(Chang *et al.*, 1987a, b; Choi *et al.*, 1996; Yun *et al.*, 1996). In steady state of grassland ecosystem, the velocity of net change in annual addition of elements into soil is equal to that of the annual removal. Present investigation is to determine decay rates of micronutrients, copper, 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 0.25m. Biomass was calculated as weights of air-dried fractions. Zinc and copper were measured according to Allen's method(Allen *et al.*, 1974). Boiling a 100ml Kjeldahl flask including adding orderly

1ml, 60% $HClO_4$, 5ml conc. HNO_3 and 0.5ml conc. H_2SO_4 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. Quantify this extracts(324.8nm wavelength) by atomic absorption 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.*(1987a, b, 1995a, b).

RESULTS AND DISCUSSION

The annual production and decay, and cycle of copper were investigated at a steady state in *Zoysia japonica* and *Miscanthus sinensis* grassland ecosystems in Mt. Kwanak, Korea. Amounts of copper in surface soil such as litter, fermentation, humus and A_1 layers were shown in Table 1. And decay half time and times needed to decay 95% and 99% of initial amounts were shown in Table 2. Total average storage of copper were 23.92mg /m^2 in *Z. japonica*, and 51.82mg /m^2 in *M. sinensis* grassland. Inputs of litters of *Z. japonica* were not more than those of litters of *M. sinensis*. As this, copper was added to soil surface in *M. sinensis* grassland.

Elements in litter layers 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 on the base of experimental and mathematical model(Chang and Yoshida, 1973). Decay constants for copper were 0.18 in *Z. japonica* grassland, and 0.30 in *M. sinensis* grassland(Fig. 1). Decay half times of copper were 3.85 years in *Z. japonica* and 2.31

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

Horizon	*Zoysia japonica*(mg /m^2)	*Miscanthus sinensis*(g /m^2)
L	4.31	15.57
F	6.06	9.14
H	3.27	22.49
A_1	10.28	4.62

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

Parameter	*Zoysia japonica*	*Miscanthus sinensis*
k	0.18	0.30
1 /k	5.56	3.33
$t_{.50}$ (years)	3.85	2.31
$t_{.95}$ (years)	16.68	9.99
$t_{.99}$ (years)	27.80	16.65

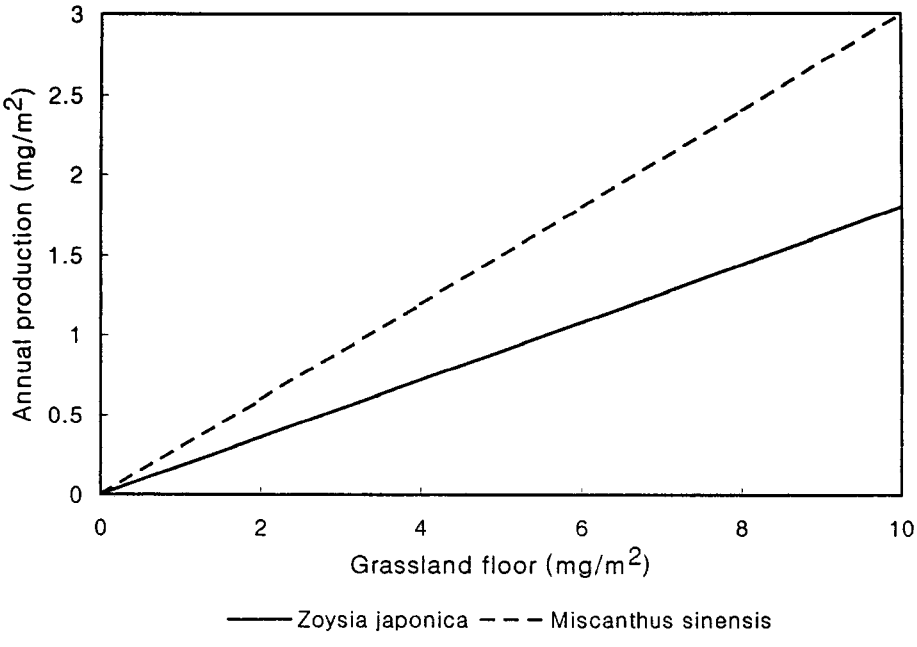

Fig. 1. Estimates of decay constants for copper in *Zoysia japonica* and *Miscanthus sinensis* at steady state grassland floor in Mt. Kwanak.

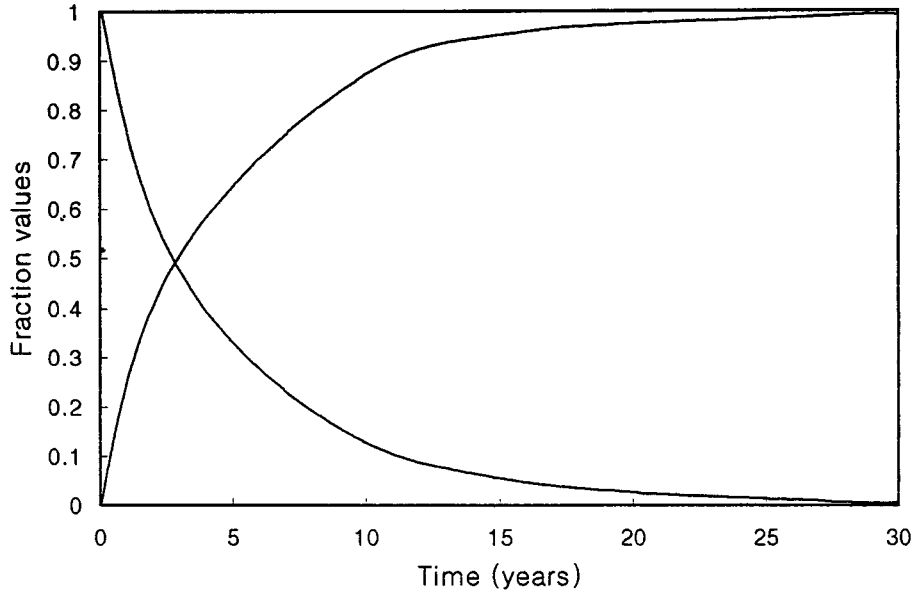

Fig. 2. Relation between the accumulation and decomposition of copper from litters of *Zoysia japonica* at steady state grassland floor in Mt. Kwanak.

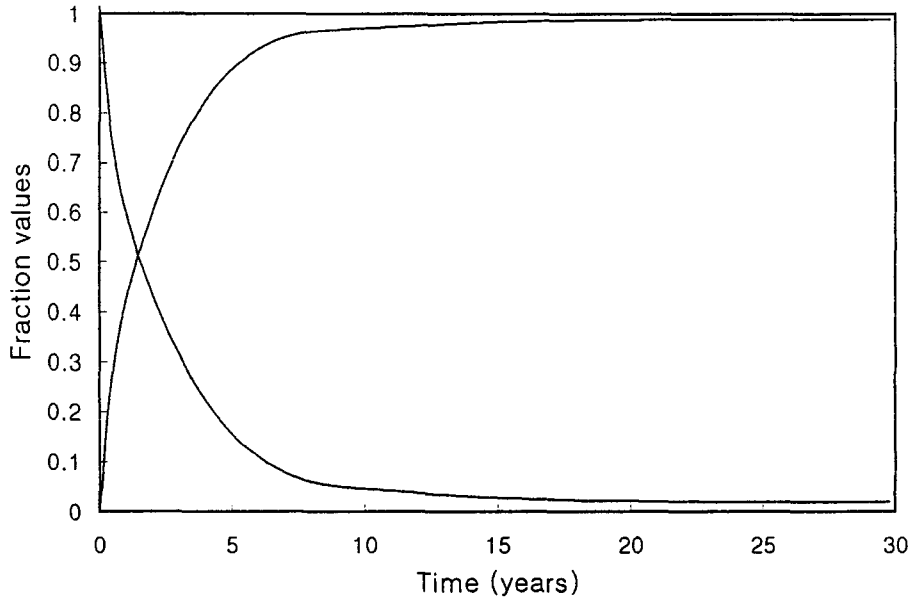

Fig. 3. Relation between the accumulation and decomposition of copper from litters of *Miscanthus sinensis* at steady state grassland floor in Mt. Kwanak.

in *M. sinensis*. 95% decay time were 16.68 years in *Z. japonica*, and 9.99 years in *M. sinensis*. Needed times to decay almost all of elements in *Z. japonica* and *M. sinensis*, were 27.80 years, and copper 16.65 years respectively. The copper was losed more rapidly in *M. sinensis* than in *Z. japonica*(Fig. 2~3). For there were more leaching and litter decomposition by microbes in *M. sinensis* grassland.

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). Yun *et al.*(1996) reported the removal constants in the littoral grassland of *Phragmites*, *Misacnthus*, *Scirpus* and *Typha* in the lake Paldangho in Gyounggi-do, South Korea. Removal constants of copper was smaller than others'. And decay rate was more rapidly in *Misacnthus* grassland. The same was as present study. But decay constants in *Misacnthus* grassland ecosystem of littoral zones in the lake Paldangho, were 0.26 for cop-

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

Fractions	Cu(mg /m²)	Fractions(%)
Live-stem	3.401	21.85
Dead-stem	2.973	19.10
Live-leaves	4.906	31.51
Dead-leaves	4.288	27.54
Total	15.568	100.00

per. For more effect of flowing by water current and leaching decomposition was in littoral zones(Shim *et al.*, 1996). More times to reach half loss, 95% loss and 99% loss of elements were needed in mountain grasslands.

The cascade of trace heavy metal copper flowed in *M. sinensis* grassland in Mt. Kwanak was shown in Table 3. The live-components as well as dead-components influenced on cycling and releasing mineral elements.

적 요

관악산의 잔디(*Zoysia japonica*)와 억새(*Miscanthus sinensis*) 초지 생태계에서 중금속 구리(Cu)의 순환에 대해서 조사하였다. 토양 내 평균 저장량은 잔디 군락에서 23.92mg /m²이었으며, 억새 군락에서는 51.82mg /m²이었다. 분해 상수는 잔디 군락에서 0.18이었으며 억새 군락에서는 0.30로 나타났다. 중금속의 초기 함량에 대한 반감기는 잔디 군락에서 3.85년, 억새 군락에서 2.31년으로 조사되었다. 초기 함량의 99% 분해하는데 소요되는 시간은 잔디 군락 구리 27.80년 및 억새 군락 16.65년으로 반감기와 마찬가지로 잔디 군락에서보다 억새 군락에서 길게 나타났다. 토양의 표층 내에 있는 구성 성분의 분해 속도는 잔디 군락에서 억새 군락보다 빠르게 진행하는 것으로 나타났다.

REFERENCES

1. Allen, S. E., H. M. Grimshaw, J. A. Parkinson and C. Quarmby. 1974. Chemical analysis of Ecological Materials. Blackwell Sci. Pub., Oxford, UK. pp. 119-236.
2. Brady, N. C. 1990. The Nature and Properties of Soils(10 eds.). Macmillan Pub. Co. New York.
3. Chang, N. K., C. H. Bae and S. C. Kim. 1990. Effects of Air Pollution on Precipitation and Living Organisms in Seoul Area. Korean J. Ecol. 13(3): 173-180.
4. Chang, N. K., J. S. Kim, and K. M. Kang. 1995a. The Energy Flow and Mineral Cycles in a *Zoysia japonica* and a *Miscanthus sinensis* Ecosystems on Mt. Kwanak. V. The Cycles of Pottasium. Korean J. of Turf. Sci., 9(2): 109-118.
5. 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 a *Miscanthus sinensis* Ecosystems on Mt. Kwanak. Ⅱ. Organic Matter Synthesis and Decomposition Balance. Korean J. of Turf. Sci., 9(2): 109-118.
6. Chang, N. K., S. K. Lee, B. S. Lee and H. B. Kim. 1987a. The Decay Map and Turnover Cycles of Litters in Korea. Korean. J. Ecol., 10(4): 183-193.
7. Chang, N. K., S. K. Lee, B. S. Lee and H. B. Kim. 1987b. The Litter Accumulation, Decay and Turnover Models and their Validation. Korean. J. Ecol., 10(3): 139-149.
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 Graal. Sci., 19: 341-357.

9. 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* Grassland in the delta of the Nakdong River. Korean J. of Turf. Sci., 9(4): 343-350.
10. Jenny, H., S. P. Gessel and F. T. Bingham. 1949. Comparative Study of Decomposition Rates of Organic Matter in Temperate and Tropical Regions. Soil Sci., 68: 419-432.
11. Kim, J. S. and N. K. Chang. 1996. The Energy Flow and Mineral Cycles in a *Zoysia japonica* and a *Miscanthus sinensis* Ecosystem on Mt. Kwanak. 6. The Cycles of Ca, Mg, Na. Korean J. of Turf. Sci., 10(2): 105-116.
12. Olson, J. S. 1963. Energy Storage and the Balance of Producers and Decomposers in Ecoogical System. Ecology, 44: 322-330.
13. Oohara, H., N. Yoshida and N. K. Chang. 1971. Balance of producers and decomposers in a Grassland Ecosystem in Obihiro. Ⅰ. Energy storage and Production and Decomposition of Litter. J. Japan. Grassl. Sci. 17(1): 7-18.
14. Ovington, J. D. and D. Heitkamp. 1960. Accumulation of Energy in Forest Plantation in Britain. *J. Ecol.*, 48: 639-646.
15. Pahlsson, A. B. 1989. Toxicty of Heavy Metals(Zn, Cu, Cd, Pb) to Vascular Plants. Water, Air, and Soil Pollution, 47: 287-319.
16. Park, J. K., K. C. Shim and N. K. Chang. 1996. The Removal Rates of the Constituents of Litters in the Littoral Grassland Ecosystems in the Lake Paldangho. Ⅰ. Ca, Mg. Korean J. of Turf. Sci., 10(4): 143-150.
17. Shim, K. C., K. M. Kang and N. K. Chang. 1996. The Removal Rates of the Constituents of Litters in the Littoral Grassland Ecosystems in the Lake Paldangho. Ⅰ. Organics. Korean J. of Turf. Sci., 10(2): 143-150.
18. Wallace, A. 1984. J. Plant Nutur. 7: 603-.
19. Yun, S. S., I. S. Lee and N. K. Chang. 1996. The Removal Rates of the Constituents of Litters in the Littoral Grassland Ecosystems in the Lake Paldangho. Ⅳ. Cu, Fe and Zn. Korean J. of Turf. Sci., 10(4): 297-304.