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The Removal Rates of the Constituents of Litters in the Littoral Grassland Ecosystems in the Lake Paldangho Ⅴ. Ca, Mg, and Na

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팔당호 연안대 초지생태계에서 낙엽 구성성분의 유실률 Ⅴ. Ca, Mg, Na

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ABSTRACT

This investigation was carried out to reveal the removal rates of Ca, Mg and Na among the constituents of the litters in *Phragmites communis, Miscanthus sacchariflorus, Typha angustata* and *Scirpus tabernaemontani* ecosystems in the lake Paldangho. The removal constants of Ca, Mg and Na were determined by the mathematical model and the time required to decay to any percentage of each constituent was calculated by using this model. The results obtained in this study can be abstracted as follows ;

The removal constants of Ca, Mg and Na of the litters were 0.91, 0.86 and 0.71 in *Phragmites communis*, 0.64, 0.62, and 0.50 in *Miscanthus sacchariflorus*, 0.66, 0.28, and 0.56 in *Typha angustata* and 0.40, 0.55 and 0.63 in *Scirpus tabernaemontani*, respectively. These values of each constituent in *Phragmites communis* are the highest among the compared species and in each species, Ca among the studied constituent is higher than the others.

The half times of Ca, Mg and Na required for the removal or accumulation of the litters on the grassland floor were 0.76, 0.80 and 0.98 years in *Phragmites communis*, 1.08, 1.12 and 1.39 years in *Miscanthus sacchariflorus* 1.05, 2.47 and 1.24 years in *Typha angustata* and 1.73, 1.26 and 1.10 years in *Scirpus tabernaemontani*, respectively.

Key words: Removal constant, *Phragmites communis, Miscanthus sacchariflorus, Typha angustata, Scirpus tabernaemontani*, Paldangho. Ca, Mg, Na.

INTRODUCTION

Organic materials added to the aquatic ecosystem will be decomposed by microorganisms or removed by rainfall or water flow. The ratio of annual production and loss of the litter in plant ecosystems affords a reliable index to evaluate the mineral nutrient cycles and the water conditions. Numerous investigators(Greenland and Nye, 1956; Jenny *et al.*, 1959; Olson, 1963; Oohara *et al.*, 1971; Chang and Yosida, 1973; Kim and Jang, 1975; Chang *et al.*, 1987) have used the mathematical model to describe the changes of mineral nutrient elements in soil as a function of time. This is exponential function derived from radioactive decay model. By applicating it, a few available data were reported on the removal rates of the constituents of litters in the aquatic ecosystems(Chang and Oh, 1995; Chang and Ahn, 1995).

According to Oohara *et al.* (1971a, b, c), Chang and Yoshida(1973) and Chang *et al.* (1987), there were differences among the decay velocities of the various organic constituents and each decay rate of the organic constituents had highly significant differences among species. Kim and Chang(1975) working with the oak and pine forests found that factors affecting the decomposition rates of the litter are humus, organic carbon, moisture content, calcium, phosphorus and nitrogen and reported that the amount of mineral nutrients returned annually to soil was higher in the oak than in the pine forest.

In the present study, by using the mathematical model, the information for accumulation and removal of Ca, Mg and Na in the aquatic ecosystems in the lake Paldangho was elucidated and compared among four species. The purpose of this study was to estimate the removal rate of each mineral component and understand the turnover and cycles of Ca, Mg and Na in a *Phragmites communis, Miscanthus sacchariflorus, Typha angustata* and *Scirpus tabernaemontani* ecosystems in the lake Paldangho.

MATERIALS AND METHODS

The litter samples were collected by the quadrat method from the L, F, H and A_1 horizons in the *P. communis, M. sacchariflorus, T. angustata* and *S. tabernaemontani* ecosystems in the lake Paldangho. The litter production was calculated on a dry weight basis. Mineral elements were estimated as the difference between the inorganic elements extracted from comparable ignited at 550℃ and unignited samples. The levels of each elements in these extracts were determined by the flame photometry and an atomic absorption spectrophotometer (Model 303).

RESULTS AND DISCUSSIONS

The site selected for this study is the aquatic grassland floor of *P. communis, M. sacchariflorus, T. angustata* and *S. tabernaemontani* in the lake Paldangho. The annual production and removal of Ca, Mg and Na on the grassland floor were estimated in this area.

1. Annual productions of Ca, Mg and Na in the aquatic grassland ecosystems

Table 1 shows that annual productions of Ca, Mg and Na of the litter in the Paldangho were average 6.60, 1.72 and 0.72g/m^2 in *P. communis*, 2.30, 0.68 and 0.93g/m^2 in *M. sacchariflorus*, 38.51, 2.72 and 3.50g/m^2 in *T. angustata* and 5.61, 2.27, 2.22 in *S. tabernaemontani*, respectively. As shown Table 1, the amounts of the annual production and accumulation of Ca, Mg and Na were very high in *T. angustata* and low in *P. communis* and *M. sacchariflorus*. Fig. 1, Fig. 2 and Fig. 3 present a wide range in Ca, Mg and Na production, plotted along the vertical axis in terms of grams of Ca, Mg and Na per square meter per year. In each figure, under the assumption that the grassland floors in the studied sites may be approximately a steady state, the removal constant, r can be estimated from the ratio of the vertical and horizontal coordinates of each point in the figures.

2. The estimates of the removal constants for Ca, Mg and Na

To compare with the removal rates of Ca, Mg and Na in each species, the estimates of the removal rates, r_1(*P. communis*), r_2(*M. sacchariflorus*), r_3(*T. angustata*) and r_4(*S. tabernaemontani*) for Ca, r_5, r_6, r_7 and r_8 for Mg and r_9, r_{10}, r_{11} and r_{12} for Na, were calculated from the ratio of the annual production to the steady state accumulation on the aquatic grassland floor of *P. communis*, *M. sacchariflorus*, *T. angustata* and *S. tabernaemontani* ecosystems. These data were indicated in Table 2, Fig. 1, Fig. 2 and Fig. 3.

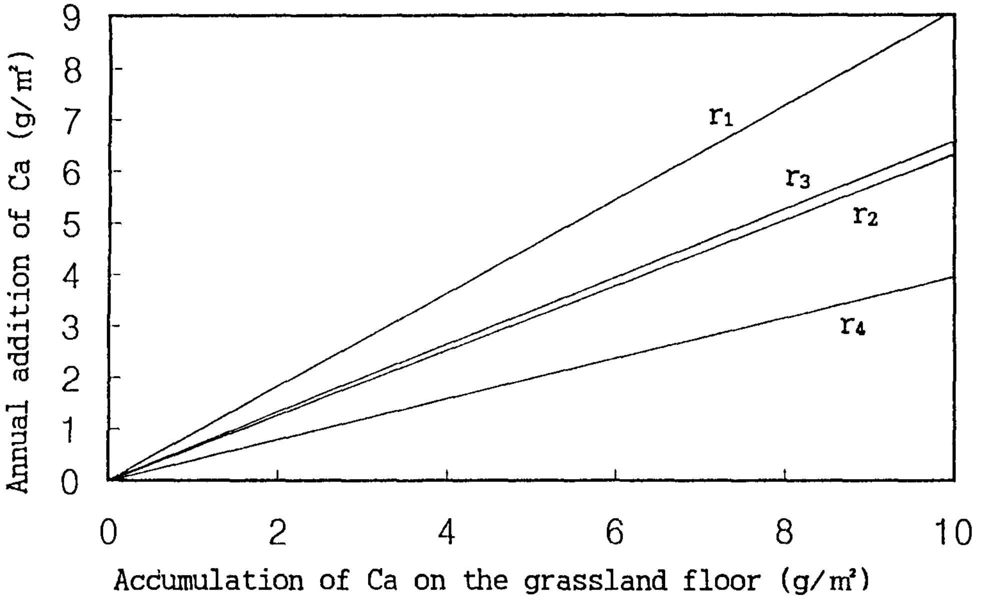

Fig. 1. Estimates of removal rate, r for Ca in the aquatic grassland of *P. communis*(r_1), *M. sacchariflorus*(r_2), *T. angustata*(r_3) and *S. tabernaemontani*(r_4) from the ratio of annual Ca-production, L_{Ca}, to the approximately steady state accumulation of the grassland floor, $Css_{(Ca)}$.

Table 1. The annual production and accumulation of Ca, Mg and Na in the aquatic grassland in the lake Paldangho

Species	Horizon	Dry weight (g/m^2)	Organic Matter(g/m^2)	Ca (g/m^2)	Mg (g/m^2)	Na (g/m^2)
Phragmites	*L*	3,550.4	3,342.4	6.60	1.72	0.72
communis	*Css*	810.4	702.7	0.68	0.28	0.30
Miscanthus	*L*	3,440.0	3,334.1	2.30	0.68	0.93
sacchariflorus	*Css*	2,728.9	2,541.3	1.30	0.41	0.93
Typha	*L*	8,308.8	8,004.0	38.51	2.72	3.50
angustata	*Css*	7,557.6	6,005.8	19.58	6.88	2.75
Scirpus	*L*	6,136.0	5,963.5	5.61	2.27	2.22
tabernaemontani	*Css*	3,111.2	1,968.9	8.38	1.85	1.29

From the data of Table 2, removal rates of Ca were 0.91 in *P. communis*, 0.64 in *M. sacchariflorus*, 0.66 in *T. angustata* and 0.40 in *S. tabernaemontani*. These values were 0.86, 0.62, 0.28 and 0.55 for Mg and 0.71, 0.50, 0.56 and 0.63 for Na, respectively. According to these data, it could be said that the removal rates of Ca, Mg and Na in *P. communis* was higher than the other species. In each species, removal constant of Ca, was the highest among the surveyed constituents except that of *S. tabernaemontani*.

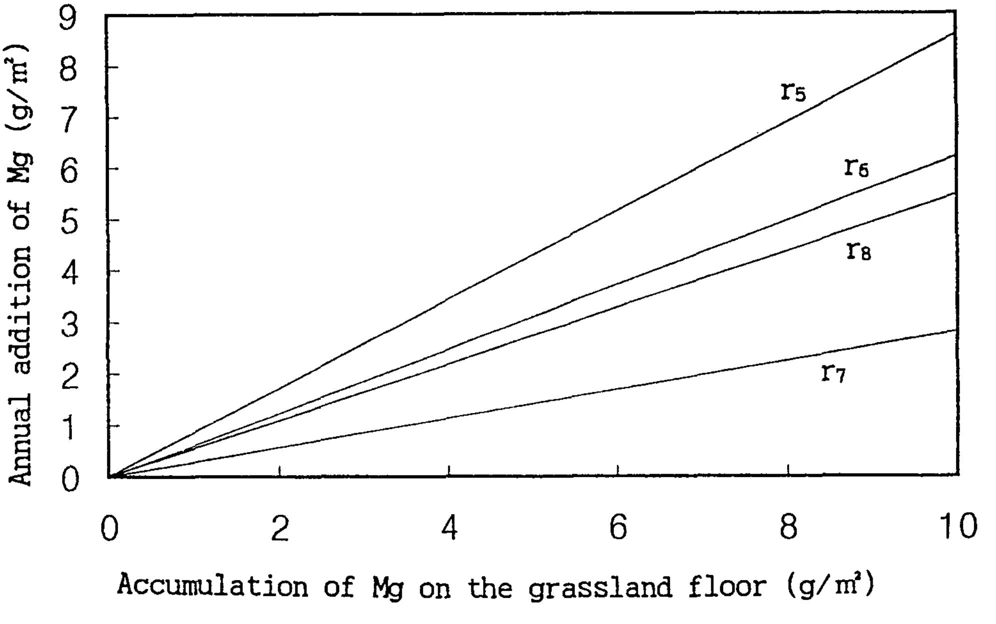

Fig. 2. Estimates of removal rate, r for Mg in the aquatic grassland of *P. communis*(r_5), *M. sacchariflorus*(r_6), *T. angustata*(r_7) and *S. tabernaemontani*(r_8) from the ratio of annual Mg-production, L_{Mg}, to the approximately steady state accumulation of the grassland floor, $Css_{(Mg)}$.

Table 2. The parameter and periods(year) for removal and accumulation of Ca, Mg and Na in the aquatic grassland in the lake Paldangho

Species	Organic constituent	Constant r	$1/r$	Half time $r_{0.5}$	95% time $r_{0.95}$	99% time $r_{0.99}$
Phragmites communis	Ca	0.91	1.10	0.76	3.30	5.50
	Mg	0.86	1.16	0.80	3.48	5.80
	Na	0.71	1.41	0.98	4.23	7.05
Miscanthus sacchariflorus	Ca	0.64	1.56	1.08	4.68	7.80
	Mg	0.62	1.61	1.12	4.83	8.05
	Na	0.50	2.00	1.39	6.00	10.00
Typha angustata	Ca	0.66	1.52	1.05	4.56	7.60
	Mg	0.28	3.57	2.47	10.71	17.85
	Na	0.56	1.79	1.24	5.37	8.95
Scirpus tabernaemontani	Ca	0.40	2.50	1.73	7.50	12.50
	Mg	0.55	1.82	1.26	5.46	9.10
	Na	0.63	1.59	1.10	4.77	7.95

The increasing order of the removal constants of the elements was Na, Mg and Ca in *P. communis* and *M. sacchariflorus*. In agreement with the results of Oohara *et al.* (1971c) and

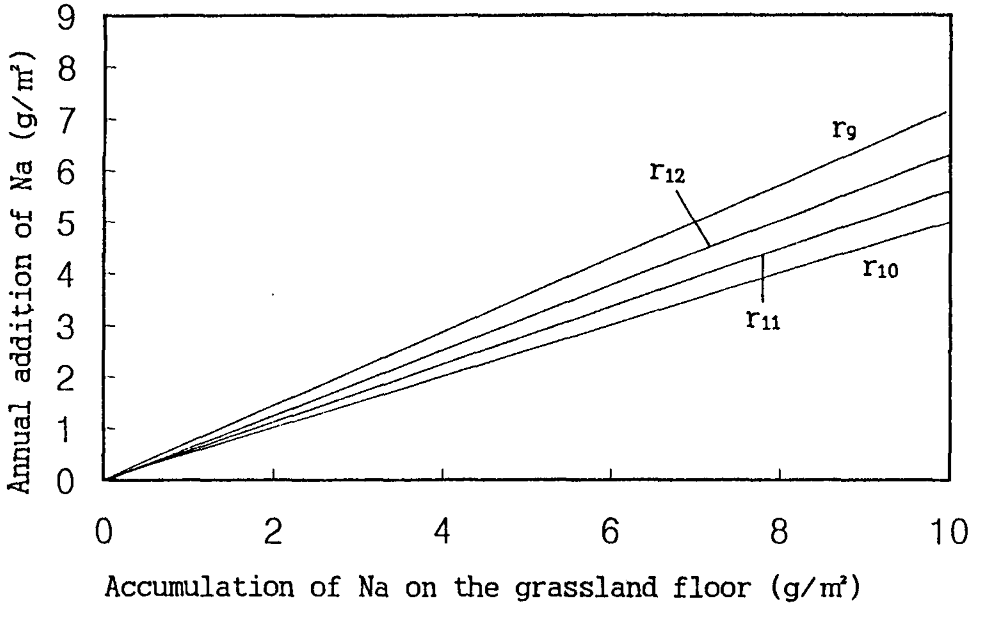

Fig. 3. Estimates of removal rate, r for Na in the aquatic grassland of *P. communis*(r_9), *M. sacchariflorus*(r_{10}), *T. angustata*(r_{11}) and *S. tabernaemontani*(r_{12}) from the ratio of annual Na-production, L_{Na}, to the approximately steady state accumulation of the grassland floor, $Css_{(Na)}$.

Chang *et al.* (1987), Ca was removed faster than any other analysed elements. However, this order was Mg, Na and Ca in *T. angustata* and Ca, Mg and Na in *S. tabernaemontani*. It seems that difference of the fraction of Ca, Mg and Na among species is due to not only the wide variation between Ca, Mg and Na contents and annual productions of the litter but also their contents of the soil profiles and their levels of the annual litter(Oohara *et al.*, 1971b). And Brinson(1977) also reported that rates of loss of the nutrients were significantly different between sites.

3. The turnover of Ca, Mg and Na in the aquatic grassland ecosystems

Oohara *et al.* (1971a,b) and Chang and Yoshida(1973) induced the basic concepts for the removal and accumulation models of each organic constituent, and the total models of the organic constituents were expressed in the weight loss proportional to the amount remaining at any one time. Table 2 presents these data for the litter which are accumulated and removed in the aquatic grassland ecosystems. Gradually rising exponential increments for accumulation under the conditions of the steady additions and losses of the litter were expressed in Fig. 4, Fig. 5, Fig. 6 and Fig. 7. The removal curves are the mirror images of the curves for accumulation on the grassland floor.

The times required to remove 50 percent of accumulated Ca, were 0.76 in *P. communis*, 1.08 in *M. sacchariflorus*, 1.05 in *T. angustata* and 1.73 years in *S. tabernaemontani*. These values for Mg were 0.80, 1.12, 2.47 and 1.26 years and for Na were 0.98, 1.39, 1.24 and 1.10 years, respectively.

In addition, the periods from organic Ca to 95% of exchangeable Ca, $r_{0.95(Ca)}$, were 3.30 in *P. communis*, 4.68 in *M. sacchariflorus*, 4.56 in *T. angustata* and 7.50 years in *S. tabernaemontani*. The $r_{0.95(Mg)}$ for Mg were 3.48, 4.83, 10.71 and 5.46 years and $r_{0.95(Na)}$ for Na were 4.23, 6.00, 5.37 and 4.77 years, respectively.

The theoretical curves of removal or turnover of the constituent Ca, Mg and Na for the litter in *P. communis* are shown in Fig. 4. These mathematical models for *P. communis* grassland are given as follows (Chang and Ahn, 1995);

$$[Ca] = 7.28\, e^{-0.91t}$$
$$[Mg] = 2.00\, e^{-0.86t}$$
$$[Na] = 1.02\, e^{-0.71t}$$

where [Ca], [Mg] and [Na] is Ca, Mg and Na content of the remainings for the litter and Ca_0, Mg_0 and Na_0 is the level of the initial Ca, Mg and Na.

And the models of Ca, Mg and Na accumulation on the *P. communis* grassland floors are as follows ;

$$[Ca]_A = 7.28\,(1-e^{-0.91t})$$
$$[Mg]_A = 2.00\,(1-e^{-0.86t})$$
$$[Na]_A = 1.02\,(1-e^{-0.71t})$$

Table 3. Models for removal and accumulation of Ca, Mg and Na in the aquatic grassland ecosystem of the lake Paldang-ho

Species	Removal models	Accumulation models
P. communis	[Ca] = $7.28\,e^{-0.91t}$	$[Ca]_A$ = $7.28\,(1-e^{-0.91t})$
	[Mg] = $2.00\,e^{-0.86t}$	$[Mg]_A$ = $2.00\,(1-e^{-0.86t})$
	[Na] = $1.02\,e^{-0.71t}$	$[Na]_A$ = $1.02\,(1-e^{-0.71t})$
M. sacchariflorus	[Ca] = $3.60\,e^{-0.64t}$	$[Ca]_A$ = $3.60\,(1-e^{-0.64t})$
	[Mg] = $1.09\,e^{-0.62t}$	$[Mg]_A$ = $1.09\,(1-e^{-0.62t})$
	[Na] = $1.86\,e^{-0.50t}$	$[Na]_A$ = $1.86\,(1-e^{-0.50t})$
T. angustata	[Ca] = $58.09\,e^{-0.66t}$	$[Ca]_A$ = $58.09\,(1-e^{-0.66t})$
	[Mg] = $9.60\,e^{-0.28t}$	$[Mg]_A$ = $9.60\,(1-e^{-0.28t})$
	[Na] = $6.25\,e^{-0.56t}$	$[Na]_A$ = $6.25\,(1-e^{-0.56t})$
S. tabernaemontani	[Ca] = $13.99\,e^{-0.40t}$	$[Ca]_A$ = $13.99\,(1-e^{-0.40t})$
	[Mg] = $4.12\,e^{-0.55t}$	$[Mg]_A$ = $4.12\,(1-e^{-0.55t})$
	[Na] = $3.51\,e^{-0.63t}$	$[Na]_A$ = $3.51\,(1-e^{-0.63t})$

Then, the exponential models for removal and accumulation of Ca, Mg and Na in each species is shown in Table 3.

According to Daubenmire and Prusso(1963), the rates of decay for plant litters would appear to be governed by three factors : (1)the physicochemical properties of the substrate, (2)the environment under which decay takes place, and (3)the species active

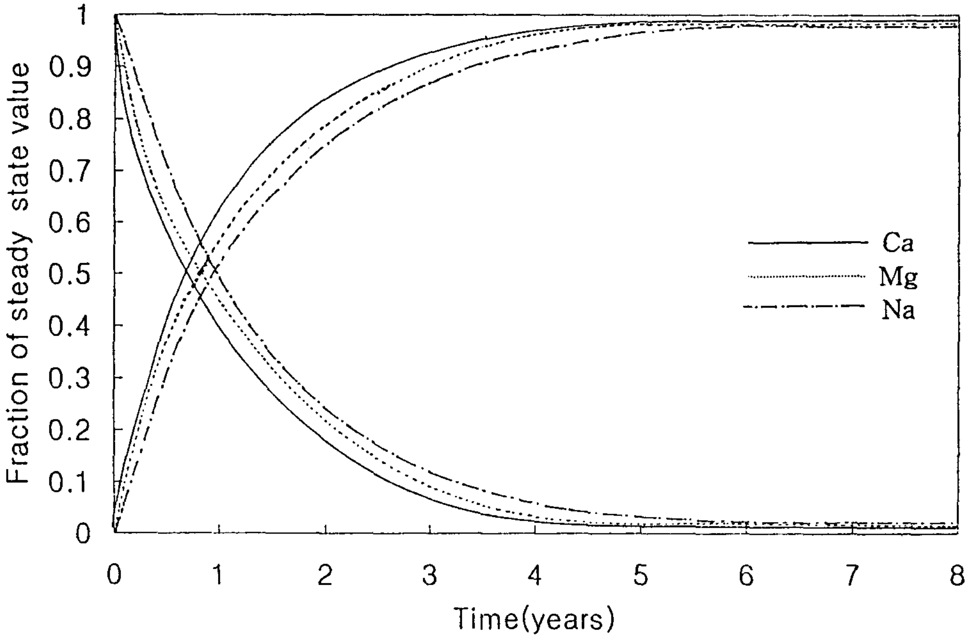

Fig. 4. The exponential curves for accumulation and removal of Ca, Mg and Na in the aquatic grassland of *P. communis* ecosystems in the lake Paldangho.

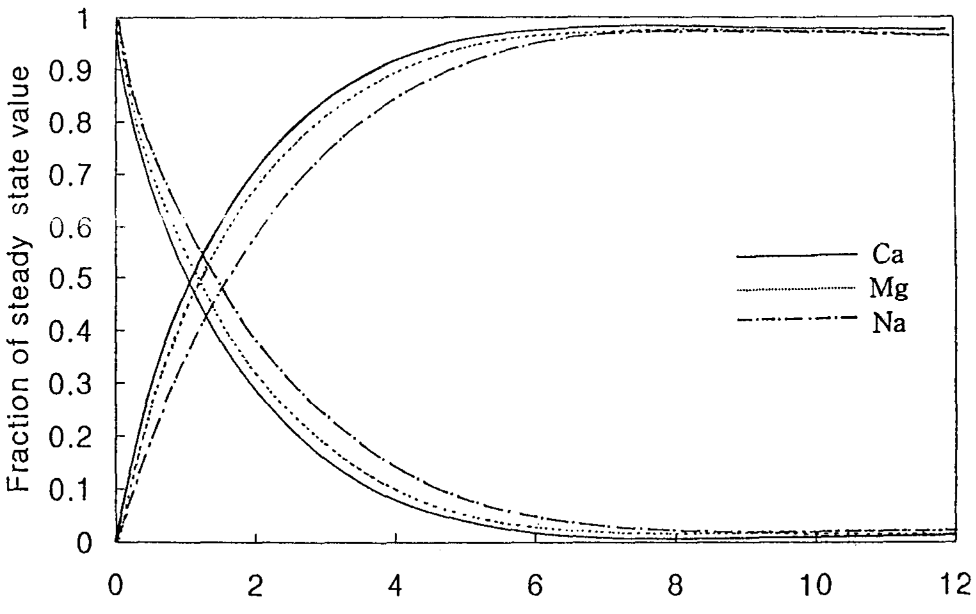

Fig. 5. The exponential curves for accumulation and removal of Ca, Mg and Na in the aquatic grassland of *M. sacchariflorus* ecosystems in the lake Paldangho.

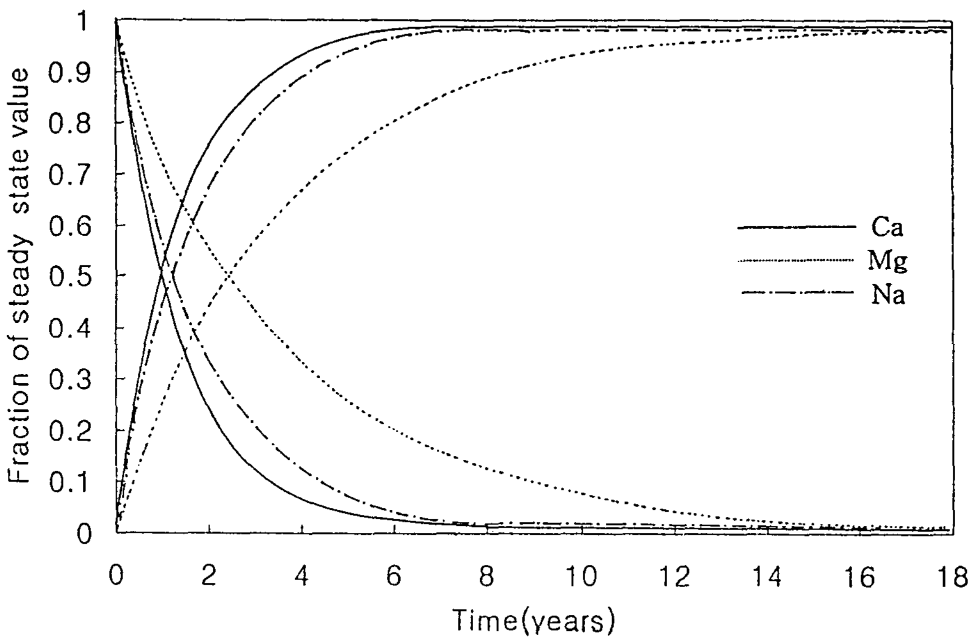

Fig. 6. The exponential curves for accumulation and removal of Ca, Mg and Na in the aquatic grassland of *T. angustata* ecosystems in the lake Paldangho.

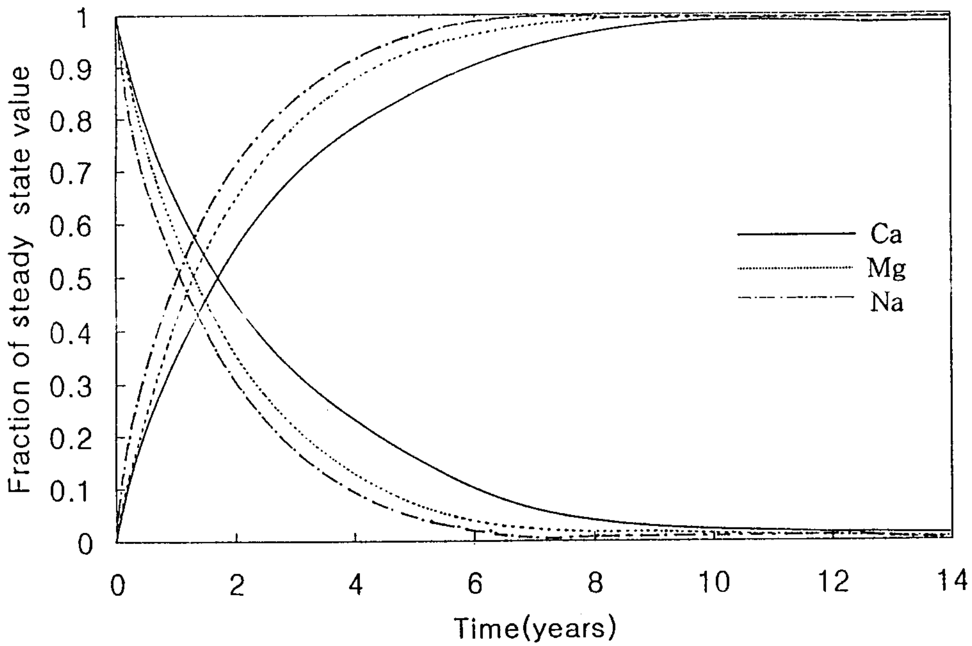

Fig. 7. The exponential curves for accumulation and removal of Ca, Mg and Na in the aquatic grassland of *S. iabernaemontani* ecosystems in the lake Paldangho.

under the particular substantial and environmental conditions.

As this results compared with the study of Chang *et al.* (1987, 1995a,b,c,d), Chang and Ahn(1995) and Chang and Oh(1995), there were difference between the removal rates in the aquatic grassland ecosystems and those in the terrestrial grassland ecosystems. Their reports showed that the former is much higher than the latter. This is interpreted by the facts that in the aquatic grassland ecosystems, the larger values of the removal constants is mainly not due to decay of litters but leaching and flowing of water soluble fraction by snow or rain. In particular, this removal phenomenon of nutrients by rainfall and water flow is concentrated on summer(from June to September) under the Korean natural climate. And in summer, water soluble fractions such as Ca, Mg and Na melted in water flow at a high temperature on the aquatic grassland floors, then leached into the mineral soil or removed.

적 요

팔당호의 갈대, 억새, 부들, 고랭이 생태계에 있어서의 낙엽의 구성성분 중 Ca, Mg, Na의 유실률을 조사하였다. Ca, Mg, Na에 대한 유실상수는 수학적 모델에 의해 결정하였고, 이 모델을 사용하여 각각의 구성성분이 일정한 양까지 줄어드는데 걸리는 시간을 추정하였다.

낙엽의 구성성분중 Ca, Mg, Na에 대한 유실상수는 갈대가 각각 0.91, 0.86, 0.71, 억새에서는 0.64, 0.62, 0.50이었으며, 부들에서는 0.66, 0.28, 0.56, 그리고 고랭이에서는 0.40, 0.55, 0.63 으로 나타났다. 각 구성성분에 대한 유실상수는 Ca, Mg, Na 모두 갈대에서 가장 크게 나타났으며, 조사된 구성성분들 중에서는 Ca가 가장 큰 값을 보였다.

팔당호의 수생생태계에 있어서의 낙엽의 Ca, Mg, Na의 유실과 축적에 대한 점근선의 절반에 도달하는데 걸리는 시간은 갈대에서 0.76, 0.80, 0.98년, 억새에서 1.08, 1.12, 1.39년, 부들에서 1.05, 2.47, 1.24년, 고랭이에서는 1.73, 1.26, 1.10년이었다.

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