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Nitrogen and Phosphorus Dynamics in a Salt Marsh in the Nakdong River Estuary

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洛東江 河口 塩濕地 植物群落의 窒素 및 燐의 動態

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ABSTRACT

We studied primary production, nitrogen and phosphorus dynamics in a salt marsh of Okryutung at Nakdong River estuary. The standing biomass in *Phragmites longivalvis, Carex scabrifolia* and *Zoysia sinica* stand was 5.48 kg/m^2, 1.94 kg/m^2 and 1.95 kg/m^2, respectively. The peak above-ground biomass in each stand was 1.99 kg/m^2, 0.74 kg/m^2 and 1.03 kg/m^2, respectively. Soil nitrogen decreased from the onset of growing season till July, and then increased. Seasonal patterns of soil phosphorus were different from stand to stand. Nitrogen concentrations of above-ground plant tissue were quite different among the plant species at the very beginning of the growing season, however, they became similar as the plants grow. Seasonal pattern of phosphrous in *C. scabrifolia* roots was quite different from those other two species. Nitrogen absorbed by plants during the growing season in *P. longivalvis, C. scabrifolia* and *Z. sinicia* stand was 224 kg/ha, 111 kg/ha and 156 kg/ha, respectively. Phosphorus taken up by plants was 22 kg/ha, 29 kg/ha and 21 kg/ha, respectively. Because the vascular plants growing at salt marshes can immobilize large quantities of nitrogen and phosphorus, salt marsh vegetation can be used for preventing the pollution of coastal sea water.

INTRODUCTION

Estuaries are known to be highly productive areas. They are often more productive than adjacent saltwater or freshwater areas and serve as nursery grounds for many animal species. Salt marsh is an important component of the estuary, contributing organic and inorganic nutrients to the water which enables them to support such an abundance of life.

There are many reports on the production of salt marsh communities (Odum, 1959, 1961; McNaughton, 1966; Reimold and Linthurst, 1977). *Phragmites longivalvis* marshes have been found to be highly productive in Korea (Oh, 1970; Kim *et al.*, 1972; Mun, 1984). This excess production is an important energy and nutrient source for surrounding areas (Odum and de la Cruz, 1967). This is supported by Teal's (1962) work in which he found that approximately 45% of the production of a Georgia *Spartina* marsh was exported to surrounding waters.

Nutrient cycling in salt marshes has been found to be very complex due to the interaction of many marsh components as well as the influence exerted by freshwater and tidal flow. Within the salt marsh ecosystem, energy and carbon utilized by heterotrophs may be derived either from materials imported with the tides or from plant materials produced *in situ.* Grant and Patrick (1970) reported that water flowing out from the marsh contained much less phosphorus and nitrogen than the water flowed into the marsh earlier. Since then, saltmarsh processes of waste-water purification are acknowledged (Patrick *et al.*, 1971; Sweet, 1971; Valiela and Teal, 1972; Gosselink *et al.*, 1974; Queen, 1977).

The objectives of this study were to estimate the production and nutrients absorption by salt marsh plant communities, and to examine the possible role of salt marsh plants as waste-water purifier at the Nakdong river estuary.

METHODS

The study area was described in a previous paper (Kim *et al.*, 1986). Three stands were developed in this study site: *Phragmites longivalvis, Carex scabrifolia* and *Zoysia sinica,* which were typical of salt marshes in the Nakdong river estuary. They were almost pure except for the boundary areas which were mixed with both species adjoining each other. Most of this site submerged at high tide except for some part of high area in *P. longivalvis* stand.

For estimation of above-ground biomass, we sampled 5, 20×20 cm quadrats in each stand at every month from March to November in 1984. Reed samples were cut into 30 cm length from the base because the nutrient concentrations are different along the plant height. Rhizome and root of reed were collected by hand after excavation of soil at 60 cm depth. A steel auger, 10 cm diameter and 30 cm height, was used for quantitative measurement of below-ground biomass in *Carex* and *Zoysia* stands. There is yet not a reasonable method for the measurement of growth of perennial herbs. We assumed that the annual root dynamics (increment and decrement) were one-fourth of the average below-ground biomass according to Kucera *et al.* (1967). All the plant samples were weighed after drying at 80°C for 48 hrs, and ground for chemical analysis. Soil samples were collected every month in each stand and mud-flat. Soils were air-dried and sieved with 2 mm sieve.

Total nitrogen in plant materials and soils was determined by a modified micro-kjeldahl method (Wilde *et al.*, 1974). Plant phosphorus was determined by a wet digestion method (Allen *et al.*, 1974). Available phosphorus in soil was extracted with NH_4F extracting solution, and measured the absorbency at 660 nm with a spectrophotometer (Bray and Krutz, 1945). The amount of nitrogen and phosphorus taken up by plants annually was calculated from nitrogen and phosphorus contained in the newly produced below-ground biomass and in the above-ground biomass at the time of peak standing crop.

RESULTS

Seasonal variations of standing crops for *Phragmites longivalvis, Carex scabrifolia* and *Zoysia*

Table 1. Standing biomass, amounts of nitrogen and phosphorus immobilized by plants in each stand

	Stand		
	P. longivalvis	*C. scabrifolia*	*Z. sinica*
Standing biomass (kg/m²)			
above-ground	1.99	0.74	1.03
below-ground	3.49	1.20	0.92
total	5.48	1.94	1.95
Total amount of			
N taken up by plants (g/m²·yr)	22.4	11.1	15.6
P taken up by plants (g/m²·yr)	2.2	2.9	2.1
Maximum standing quantity of			
Nitrogen (kg/ha)	418.0	186.0	220.0
Phosphorus (kg/ha)	42.0	51.0	28.0

sinica stands were already figured in the previous paper (Kim *et al.*, 1986, Fig. 5). Out of them the peak above-ground standing crops in *P. longivalvis, C. scabrifolia* and *Z. sinica* were 1.99 kg/m², 0.74 kg/m² and 1.03 kg/m², and the peak below-ground crops in them were 3.49 kg/m², 1.20 kg/m² and 1.20 kg/m², respectively (Table 1). Much of these net production, however, were removed by freshwater and tidal flow. Some of the reed removed by man. The average below-ground biomass in each stand was 3.49 kg/m², 120 kg/m² and 0.92 kg/m², respectively (Table 1). The primary production and respiration loss in each stand were explained in the previous paper (Kim *et al.*, 1986). In seasonal variations of nutrients nitrogen concentration of reed was higher than those of other two plants (Fig. 1A). It was low at the very beginning of the growing season (34.8 mg/g), increasing in April (38.8 mg/g), and then gradually decreased (8.0 mg/g). Mun (1988) reported the same trend in the *Miscanthus sinensis.* Nitrogen concentration of *C. scabrifolia* was 19.2 mg/g at the beginning of the growing season. It decreased till August (8.5

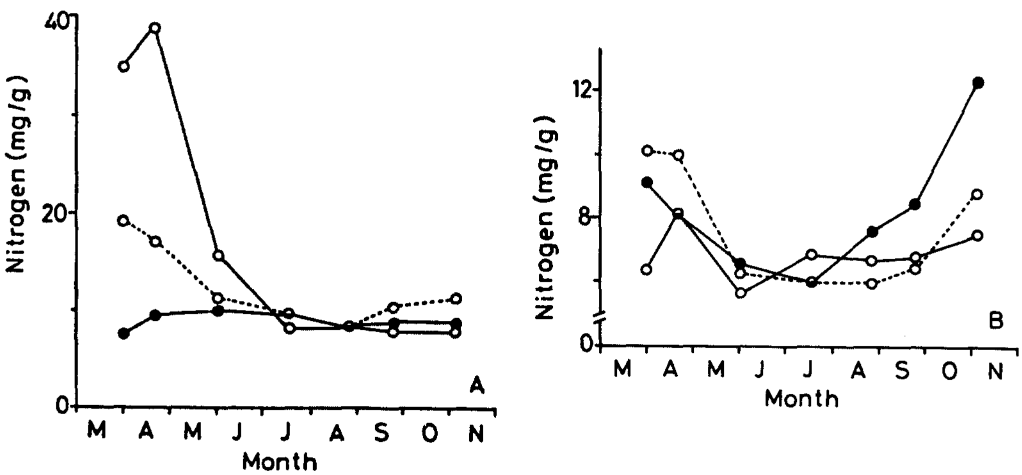

Fig. 1. Seasonal changes of nitrogen in the unit weight of above-ground (A) and below-ground (B) plant materials in study area. *P. longivalvis* stand (O——O), *C. scabrifolia* stand (O------O), and *Z. sinica* stand (●——●).

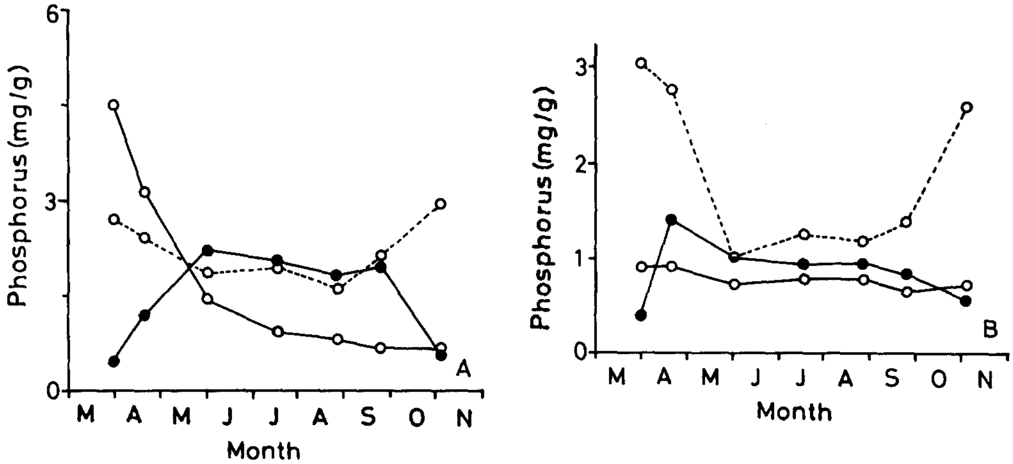

Fig. 2. Seasonal changes of phosphorus in the unit weight of above-ground (A) and below-ground (B) plant materials in the study area. Legends are the same as Fig. 1.

mg/g), and then increased in November (11.5 mg/g). This seems because new shoots are emerging in autumn. In case of *Z. sinica*, there was no significant seasonal pattern till September. However, it increased to 14.0 mg/g in November. Seasonal pattern of phosphorus concentration of *P. longivalvis* and *C. scabrifolia* was similar with that of nitrogen (Fig. 2A). However, that of *Z. sinica* was somewhat different from other two plant species. It was low at the beginning of the growing season (0.47 mg/g), increased to 2.21 mg/g in June, and then decreased to 0.56 mg/g in November. In case of *C. scabrifolia*, phosphorus content in plant tissue gradually decreased till August, and then increased. Seasonal changes of nitrogen in the below-ground tissue were similar among the plants (Fig. 1B). There was no significant seasonal patterns of phosphorus in reed and *Z. sinica*. However, phosphorus content of *C. scabrifolia* roots showed significantly seasonal pattern (Fig. 2B). At the beginning of the growing season, it amounted to 3.02 mg/g. It decreased to 1.02 mg/g in June, maintained this through September, and then increased to 2.58 mg/g in November. This indicates that nitrogen and phosphorus uptake increased for the new shoots growth in *C. scabrifolia* stand.

Soil nitrogen in mud-flat and *Carex* stand showed similar seasonal pattern. It decreased from the onset of the growing season to July, and then increased (Fig. 3A). Seasonal soil phosphorus varied from stand to stand (Fig. 3B). Soil phosphorus in *Phragmites* and *Zoysia* stands decreased from the onset of the growing season to July, and then increased significantly. Soil phosphorus in mud-flat and *Carex* stand, however, increased from the onset of the growing season till August, and then decreased. Nitrogen uptake by plants during the growing season in *P. longivalvis, C. scabrifolia* and *Z. sinica* stand amounted to 22.4 g/m^2, 11.1 g/m^2 and 15.6 g/m^2, respectively (Table 1). Nitrogen quantity in standing biomass in each stand was 418 kg/ha, 186 kg/ha and 220 kg/ha, respectively. Phosphorus taken up by plants in each stand was 2.2 g/m^2, 2.9 g/m^2 and 2.1 g/m^2, respectively. Phosphorus quantity in standing biomass in each stand was 42 kg/ha, 51 kg/ha and 28 kg/ha, respectively.

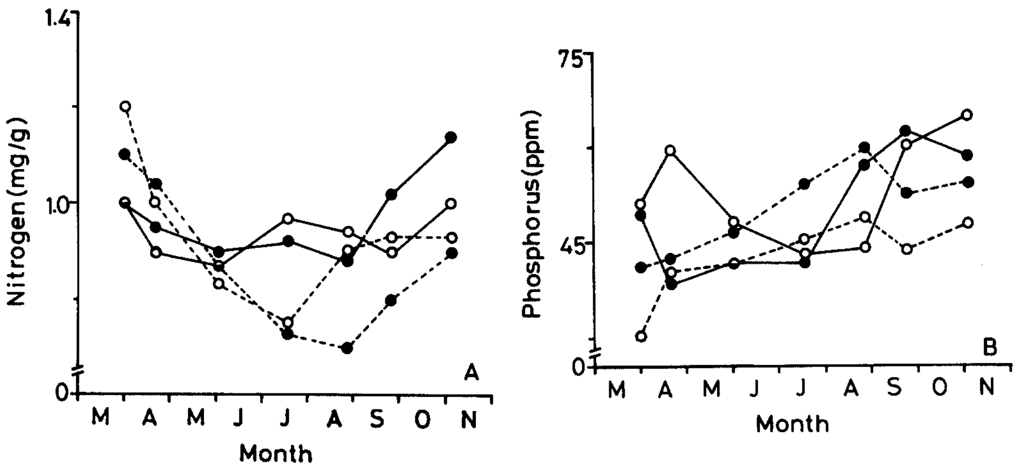

Fig. 3. Seasonal changes of nitrogen (A) and phosphorus (B) concentrations in the soil of the study area. Mud flat (●------●). Other legends are the same as Fig. 1.

DISCUSSION

Natural salt marshes remain one of the least modified habitats in the world. Recently, however, many estuaries are heavily industrialized so that pollution is a serious problem. Pollution with sewage is a major problem in coastal areas (Valiela *et al.*, 1975), which provide high-nitrogen and phosphorus to them. It has been suggested that salt marshes could be used for the polishing of effluents, as dilution sinks for treated and untreated sewage and industrial wastes, the vegetation uptake nitrogen and phosphorus from the waste water before entering the sea (Pomeroy, 1977; Long and Mason, 1983). Barnus *et al.* (1975) reported that the *Spartina alterniflora* accumulated high levels of cadmium, lead and zinc. Other workers have also reported improvements in water quality as a result of the flow of polluted water across marshes (Valiela and Teal, 1972). The nutrients immobilized by salt marsh plants can regenerate by decomposition processes which proceed through long time. This action might be effecting in preventing immediate sea water pollution.

Nitrogen and phosphorus uptake within a plant community are the results of above-and below-ground production. The standing biomass in reed stand in this study area (5.48 kg/m²) was lower than that of Eulsugdo (6.5 kg/m²) (Kim *et al.*, 1982). This difference might be due to the differences of saline condition of the soils (Min and Kim, 1983), and soil nitrogen content (Valiela and Teal, 1974). The soil nitrogen content in reed stand in this study area (average 0.94 mg/g) was consistently lower than that in Eulsugdo (average 2.50 mg/g) (Kim *et al.*, 1982). Nitrogen taken up by plants during the growing season in *P. longivalvis, C. scabrifolia* and *Z. sinica* stand was 224 kg/ha, 111 kg/ha and 156 kg/ha, respectively. Nitrogen immobilized by *P. longivalvis* was two times greater than that in *C. scabrifolia*. However, phosphorus immobilized by plants in reed stand (22 kg/ha) was lower than that in *C. scabrifolia* stand (29 kg/ha). This is because the phosphorus concentration in unit weight of plant materials in *C. scabrifolia* stand was consistently higher than that in reed stand. Considering these large quantities of nutrients immobilized by vascular plants, salt marsh vegetation can be used as waste-water purifier at the Nakdong river estuary.

摘　要

洛東江 河口 옥류등에 형성되어 있는 갈대, 천일사초 및 갯잔디 群落의 室素와 燐의 動態를 조사하였다. 室素와 燐의 흡수량 및 현존량은 植物群落의 物質生産과 단위 무게당 이들 무기영양소의 含量이 달랐다. 室素의 연 흡수량은 갈대, 천일사초, 갯잔디 群落에서 각각 224, 111 그리고 156 kg/ha이었고, 燐의 연 흡수량은 각각 22, 29 그리고 21 kg/ha이었다. 塩濕地의 관속식물 군집은 다량의 질소와 인을 흡수하기 때문에 沿岸水의 當營養化를 일시적으로 경감시키는 역할을 할 수 있는 것으로 생각되었다.

LITERATURES CITED

Allen, S.E., J.A. Parkinson, H.M. Grimshaw and C. Quaramby. 1974. Chemical analysis of ecological materials. Blackwell Sci. Publishing, Oxford, 565 pp.

Barnus, M.D., I. Valiela and J.M. Teal. 1975. Lead, zinc and cadmium budgets in experimentally enriched salt marsh ecosystems. Est. Coast. Mar. Sci. 3:421-430.

Bray, R.H. and L.T. Kurtz. 1945. Determination of total, organic and available forms of phosphorus in soils. Soil Sci. 59:39-45.

Gosselink, J.G., E.P. Odum and R.M. Pope. 1974. The value of the tidal marsh. Center for Wetland Resources, Louisiana State Univ., Baton Rouge, Publication, No. LSU-SG-74-03, 30 p.

Grant, R.R. and R. Patrick. 1970. Tinicum marsh as a water purifier. *In*,Two Studies of Tinicum Marsh. The Conservation Foundation. Washington, D.C. pp.105-123.

Kim, C.M., Y.J. Yim and Y.D. Rim. 1972. Studies on the primary production of the *Phragmites longivalvis* community in Korea. Korean IBP Report 6:1-7.

Kim, J.H., K.J. Cho, H.T. Mun and B.M. Min. 1986. Production dynamics of *Phragmites longivalvis, Carex scabrifolia* and *Zoysia sinica* stand of a sand bar at the Nagdong River estuary. Korean J. Ecol. 9:59-71.

Kim, J.H., H.S. Kim, I.K. Lee, J.W. Kim, H.T. Mun, K.H. Suh, W. Kim, D.H. Kwon, S.A. Yoo, Y.B. Ŝuh and Y.S. Kim. 1982. Studies on the estuarine ecosystem of the Nagdong river. Proc. Coll. Natur. Sci., SNU 7:121-163.

Kucera, C.L., R.C. Dahlman and R.M. Koelling. 1967. Total net productivity and turnover on an energy basis for tallgrass prairie. Ecology 48:536-542.

Long, S.P. and C.F. Mason. 1983. Salt marsh ecology. Blackie & Son Ltd. New York, 160 pp.

McNaughton, S.J. 1966. Ecotype function in the *Typha* community-type. Ecol. Monogr. 36:297-325.

Min, B.M. and J.H. Kim. 1983. Distribution and cyclings of nutrients in *Phragmites communis* communities of a coastal salt marsh. Korean J. Bot. 26:17-32.

Mun, H.T. 1984. On the plant succession of sand bars at the estuary of the Nagdong River. Ph.D. Thesis Seoul Natl. Univ., 102 pp.

Mun, H.T. 1988. Comparisons of primary production and nutrients absorption by a *Miscanthus sinensis* community in different soils. Plant and Soil 112:143-149.

Odum, E.P. 1961. The role of tidal marshes in esturine production. New York State Conservationist 15:12-15.

Odum, E.P. and A.A. de la Cruz. 1967. Particulate organic detritus in a Georgia salt marsh-estuarine ecosystem. *In*, Estuaries, G. Lauf (ed.). AAAS Sci. Pub. 83:383-388.

Oh, K.C. 1970. Quantitative ecological analysis on the terrestrial ecosystem at downstream of the Nagdong River. Proc. Study Group Natural Conservation of Korea 2:59-78.

Patrick, W.H., R.D. Delaune, D.A. Antio and R.M. Engler. 1971. Nitrate removal from water at the water-soil interface in swamps, marshes and flooded soils. Ann. Progr. Rep. PFWOA, EPA (Project 1605 FJR, LSU).

Pomeroy, L.R. 1977. Nutrients in estuaries. *In*,Coastal Ecosystem Management, J.R. Clark (ed.). Wiley and

Sons, 928pp.

Queen, W.H. 1977. Human uses of salt marshes. *In*, Ecosystems of the World I. Wet Coastal Ecosystems. V.J. Chapman (ed.). Elsevier Scientific Publishing Company, 428 pp.

Reimold, R.J. and R.A. Linthurst. 1977. Primary productivity of minor marsh plants in Delaware, Georgia and Maine. Environ. Effects Lab., U.S. Army Eng. Water Exp. Station 104 pp.

Sweet, D.C. 1971. The economic and social importance of estuaries. Environmental Protection Agency, water Quality Office, Washington, D.C. pp.49-58.

Teal, J.M. 1962. Energy flow in the salt marsh ecosystem of Georgia. Ecology 43:614-624.

Valiela, I. and J.M. Teal. 1972. Nutrient an sewage sludge enrichment experiments in a salt marsh ecosystem. Int. Symp. on Physiological Ecology of Plants and Animals in Extreme Environments, Dubrovnik.

Valiela, I., J.M. Teal and W.J. Sass. 1975. Production and dynamics of salt marsh vegetation and the effect of experimental treatment with sewage sludge. J. Appl. Ecology 12:973-981.

Wilde, S.A., R.B.Corey, J.G. Iyer and G.K. Voigt. 1979. Soil and plant analysis for tree culture. Oxford and IBH Publishing, New Delhi. 224 pp.

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