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# Mass Loss and Changes of Nutrients during Decomposition of *Phragmites communis* at the Fringe of Stream

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ABSTRACT : Mass loss and changes of mineral nutrients during decomposition of *Phragmites communis* for 13 months from November 1998 to December 1999, were investigated at the fringe of stream at Boryeong, Chungnam Province in Korea. Plant materials, which were collected in November 1998, were divided into leaves, culms and rhizomes. Litterbags, 15 x 15 cm, were made of nylon mesh with 2-mm$^2$ holes. At 13 months after installation, remaining mass of leaves, culms and rhizomes was 29.0%, 57.4%, 20.6%, respectively. Mass loss rate of the culms was significantly lower than those of the leaves and rhizomes. The decay rate of leaves, culms and rhizomes was 1.21, 0.42 and 1.48 per year, respectively. Initial concentration of N, P, K, Ca and Mg of leaves, culms and rhizomes was 22.5, 9.0, 15.5 mg/g for N, 0.34, 0.10, 0.33 mg/g for P, 15.0, 12.5, 12.3 mg/g for K, 2.84, 0.80, 0.03 mg/g for Ca, 1.94, 0.97, 0.40 mg/g for Mg, respectively. Concentrations of nutrients were higher in leaves than in culms and rhizomes. Except for N and Mg in rhizomes, there was no immobilization period during the decomposition. In the case of remaining K and Ca, most are lost during the first 3 months. Without any suitable method for removal of dead part, eutrophication of freshwater may be accelerated by dead macrophytes.

*Key Words*: Decay rate, Decomposition, Immobilization, Macrophytes, Nutrients, *Phragmites communis*.

## INTRODUCTION

Natural wetlands have recently received considerable attention as low-cost, efficient means to cleanup many types of wastewater. Wetlands are shallow-water regions dominated by emergent herbaceous vegetation such as reeds, cattails, wildrices, rushes, etc. (Hammer 1995). The emergent macrophytes constitute a significant ecological group among the plants which grow in natural wetlands (Polunin 1984).

Though the concept of deliberately using wetlands for water purification has been developed only within the last 20 years, in reality human societies have indirectly used natural wetlands for waste management (Hammer 1995). Natural wetlands can effectively remove or convert large quantities of organic matter, suspended solids, heavy metals and excess nutrients. During the growing season, wetland plants remove considerable amount of nutrients for biomass production through absorption and assimilation. After the growing season, however, most of the aboveground biomass in wetlands is put into the water body. Therefore, nutrients and organic matter can be released into the water during decomposition (Carpenter 1980).

Wetlands are among the most productive communities (Brinson *et al.* 1981). Most of these primary production, however, can remain ungrazed and the bulk of it typically enters detrital systems (Imhof 1973). The potential importance of macrophyte decay as a source of nutrients is clear (Carpenter 1980). However, decomposition processes taking place in water body are little understood (Dykyjova and Kvet 1978, Polunin 1984).

The purpose of the present study is to investigate the decay rate of *Phragmites communis*, which is one of the major emergent hydrophytes, and nutrient changes during decomposition.

## MATERIAL AND METHODS

### Litterbag preparation

At the end of the growing season in 1998, reeds were collected in a small stream, 7~8m wide and 5 km long, located at Boryeong, Chungnam Province. These materials were divided into leaves, culms and rhizomes, and used litterbag preparation after dried at 80℃ for three days. Litterbags, 15 × 15 cm, were made of nylon mesh with 2-mm$^2$ holes. We prepared 40 litterbags for each organ. Each litterbag enclosed about 5 g of litter and an aluminum tag giving the exact weight of the litter. Leaf litterbags and culm litterbags were submersed in the stream water, and rhizome litterbags were burried in the sediment in November, 1998.

### Litterbag retrieval and chemical analysis

The first retrieval of litterbags was done on December, 1998, 1-month after installation, and

then retrieved every two months till December 1999. Five-litterbags of each organ were retrieved on each sampling. Adhering soil particles and litter debris on the outside of litterbags were removed. The contents of litterbags were weighed individually after drying for 72 hr at 80℃. Each sample was ground with a mixer before the chemical analyses were carried out.

Mass loss and release of nutrients during decomposition were determined by measuring the remaining mass and nutrient concentration of litter remained in the litterbags. Mass loss of the remaining litter was expressed as % of the initial sample weight. The annual decay rate, k, is derived from the exponential decay formula,

$$-k = \ln(X/X_0)/t,$$

where $X_0$ is the dry weight initially present and $X$ is the dry weight remaining at the measurement, $t$ in years (Brinson *et al.* 1981).

Total nitrogen was determined by a modified micro-Kjeldahl method (Allen *et al.* 1974). Wet digestion method was used for phosphorus, potassium, calcium and magnesium determination. Phosphorus content was determined by a molybdenum blue color method (Allen *et al.* 1974). K, Ca and Mg were determined with an atomic absorption spectrophotometer (Perkin-Elmer 3110).

The quantity of each nutrient remaining in the litterbag at each sampling date was calculated using the concentration of nutrient in the tissue and the mass of the remaining tissue in the litterbag. The remaining quantity of each nutrient was then expressed as a percentage of the amount contained in the original tissue.

Comparisons of mean mass loss among the three organs were carried out using Student's t test with SPSS 8.0 program for Windows.

## RESULTS AND DISCUSSION

### Mass loss

Decay rate of leaves and rhizomes was significantly higher than that of culms. Leaves and rhizomes lost 49.2% and 47.8% of their initial mass over the first 7 months, respectively. However, culms lost only 14.5% of initial mass during the same period. At 13 months after installation, the remaining mass of leaves, culms and rhizomes was 29.0±3.4%, 57.4±11.7% and 20.6±6.1% of the initial mass, respectively (Fig. 1). The annual decay rate of leaves, culms and rhizomes was 1.21, 0.42 and 1.48 per year, respectively.

This difference appears to be associated with differences in rigidity and N content of substrate. Culms were more rigid than leaves and rhizomes. And nitrogen concentration of leaves and rhizomes was greater than that of culms. Polisini and Boyd (1972) reported that the culms of emergent macrophytes must resist strains from wind and surface water movement, and thus contain much structural fiber, which is slow in decomposition. Decomposition rate may be positively correlated with initial nitrogen content. High levels of nutrients in the litter have been found to give rise to a high mass loss rate (Davis and van der Valk 1978, Berg *et al.* 1982).

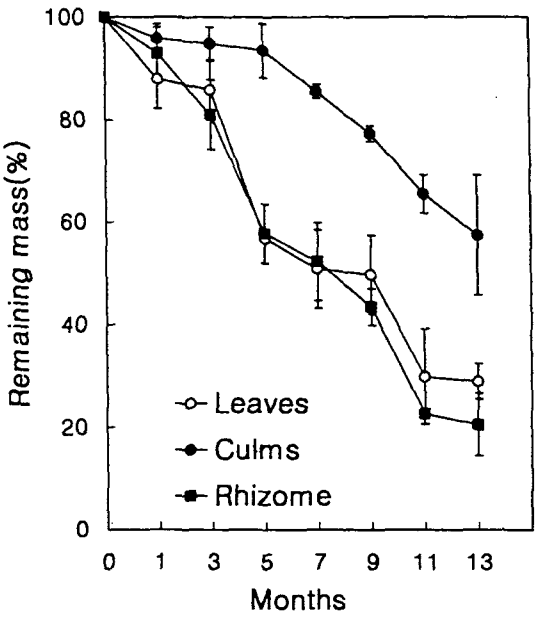


Fig. 1. Mean percent mass remaining in the decomposing organs of *P. communis*. Bars indicate standard deviation.

Mason and Bryant (1975) have reported that the annual decomposition rate of reeds leaves was 1.26. According to Brinson *et al.* (1981), it is clear that the pattern and rate of mass loss of emergent macrophytes can vary significantly between species (Polunin 1984). According to our results, rate of mass loss can vary significantly among the organs of the same species.

Polunin (1982) reported that the loss of soluble matter through leaching is particularly significant in aquatic habitats because the material is in continual contact with water (Brinson *et al.* 1981, Polunin 1984).

### Changes of nutrients

Initial N concentration of leaves, culms and rhizomes of reeds was 22.5, 9.0 and 15.5 mg/g, respectively. N concentration of culms was much lower than that in leaves and rhizomes. N con-

centration of leaves, culms and rhizomes decreased to 17.5, 7.0 and 12.0 mg/g, respectively, at one month after installation. And then increased to 23.0, 8.0 and 23.8 mg/g at 3 months after installation (Fig. 2A). Since then, N concentration of rhizomes decreased sharply, while, those of leaves and culms somewhat increased till 7 months and then decreased. At 13 months after installation, N concentration of leaves, culms and rhizomes was 16.5, 7.8 and 8.8 mg/g, respectively.

An early rapid loss of nitrogen in the litter has been noted in *P. australis* (Polunin 1982), in *Carex* spp. (Chamie and Richardson 1978). In the long-term, however, nitrogen levels may increase. The rapid loss of nitrogen within one month might be due to the loss of soluble forms of nitrogen (Polunin 1984). Anderson (1978) reported that nitrogen levels increase in *P. australis* litter in a eutrophic lake, but not in a nutrient-poor one.

Percent remaining N in each organ decreased during the first month to about 74% of the original N capital (Fig. 2B). However, remaining N of rhizomes increased to 124% at 3 months after installation. Remaining N of leaves and culms increased to 87.7 and 84.3%, respectively, at 3 months after installation and then decreased. At 13 months after installation, remaining N of leaves, culms and rhizomes was 21.3, 49.5 and 11.6%, respectively. Except for rhizomes, there was no immobilization period. Nitrogen immobilization may be due to microbial uptake (Polunin 1984).

Initial P concentration of leaves, culms and rhizomes of reeds was 0.34, 0.10 and 0.33 mg/g, respectively. P concentration of culms was much lower than those in leaves and rhizomes. P concentration of leaves decreased to 0.11 mg/g at one month and then increased thereafter (Fig. 2C). That of rhizomes decreased to 0.11 mg/g at 7 months and then increased to 0.17 mg/g at 13 months after installation. P concentration of culms decreased at one month and then gradually increased to 0.13 mg/g at 13 months after installation.

Percent remaining P in leaves and culms decreased during the first month to 29% of the initial P capital. Since then, those in culms showed gradual increase. However, remaining P of rhizomes decreased during all the experimental period (Fig. 2D). By the end of the experiment, remaining P of leaves, culms and rhizomes was 24.1, 79.5 and 10.7%, respectively.

Phosphorus may also exhibit a rapid loss in the early period of decomposition (Boyd 1970, Mason and Bryant 1975). This also may be due to the loss of soluble forms of organic matter

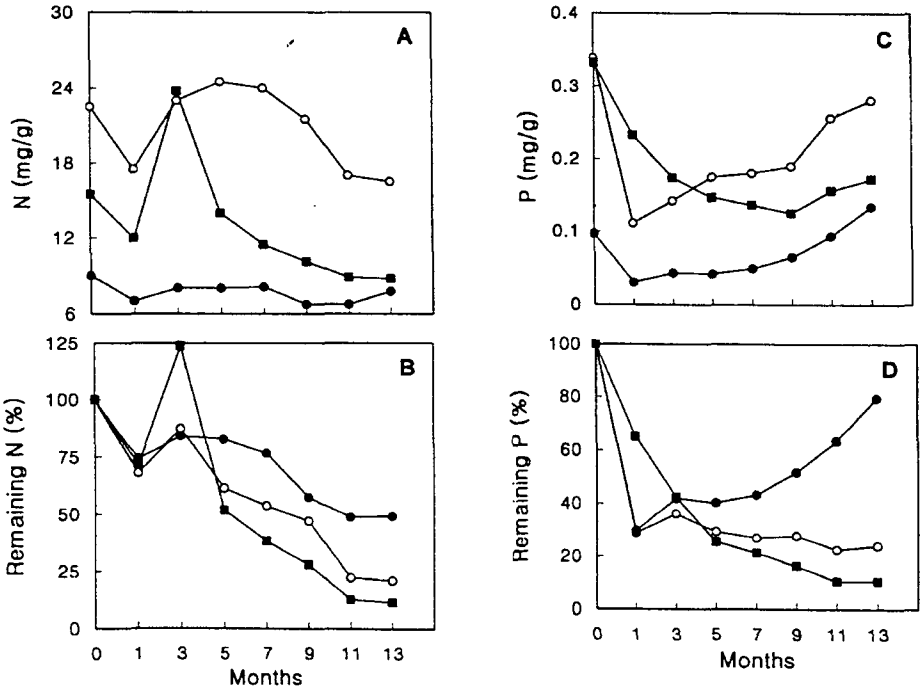


Fig. 2. Changes of N concentration (A), % of remaining N (B), P concentration (C) and % of remaining P (D) in the decomposing organs of *P. communis*. Legends are the same as in the Fig. 1.

through leaching process (Polunin 1984). There was no immobilization period in each organ during the decomposition.

Initial K concentration of leaves, culms and rhizomes of reed was 15.0, 12.5 and 12.3 mg/g, respectively. K concentration of each organ decreased sharply at one month after installation (Fig. 3A). And then it became rather constant. At one month after installation, percent remaining K in leaves, culms and rhizomes was 6.2, 4.7 and 11.2%, respectively, of the initial K capital. Nearly all of the K in each organ leached out within 3 months (Fig. 3B). The rapid loss of K was attributable to leaching. Brinson (1977) reported that about 80% of original K in *Nissa aquatica* leaves was leached out within two weeks.

Initial Ca concentration of leaves, culms and rhizomes of reeds was 2.84, 0.80 and 0.03 mg/g, respectively. Ca concentration in rhizomes was much lower than that in leaves and culms (Fig. 3C). It decreased to 0.22, 0.01 and 0.01 mg/g, respectively, at 3 months after installation. Percent remaining Ca in leaves and culms decreased to 6.8 and 4.7%, respectively, of the initial Ca capital at 3 months after installation. Percent remaining Ca in rhizomes decreased to 8.7% of the initial Ca capital at 7 months after installation (Fig. 3D). Calcium is known not to leach as readily as potassium (Planter 1970, Davis and van der Valk 1978). However, in our experiment, most of the calcium leached out rapidly like potassium (Fig. 3D).

Initial Mg concentration of leaves, culms and rhizomes of reeds was 1.94, 0.97 and 0.40 mg/g, respectively. Mg concentration of rhizomes was lower than that in leaves and culms. At one month after installation, Mg concentration of leaves decreased to 0.48 mg/g, and then showed an increasing trend. In the case of rhizomes, Mg concentration increased to 0.60 mg/g at one month after installation (Fig. 4A). At 13 months after installation, it increased to 1.06 mg/g. Percent remaining Mg in leaves and culms decreased to 22% at one month after installation. In rhizomes, however, remaining Mg increased to 141.1% at one month, and then decreased to 46.9% at 7 months after installation (Fig. 4B). Davis and van der Valk (1978) reported that Mg leached out rapidly as potassium. In our experiment, however, Mg was more resistant to leaching than potassium and calcium.

Except for nitrogen and magnesium in rhizomes, there was no immobilization period during the decomposition of reeds. In the case of remaining K and Ca, most were lost during the first 3 months. Mason and Bryant (1975) reported that

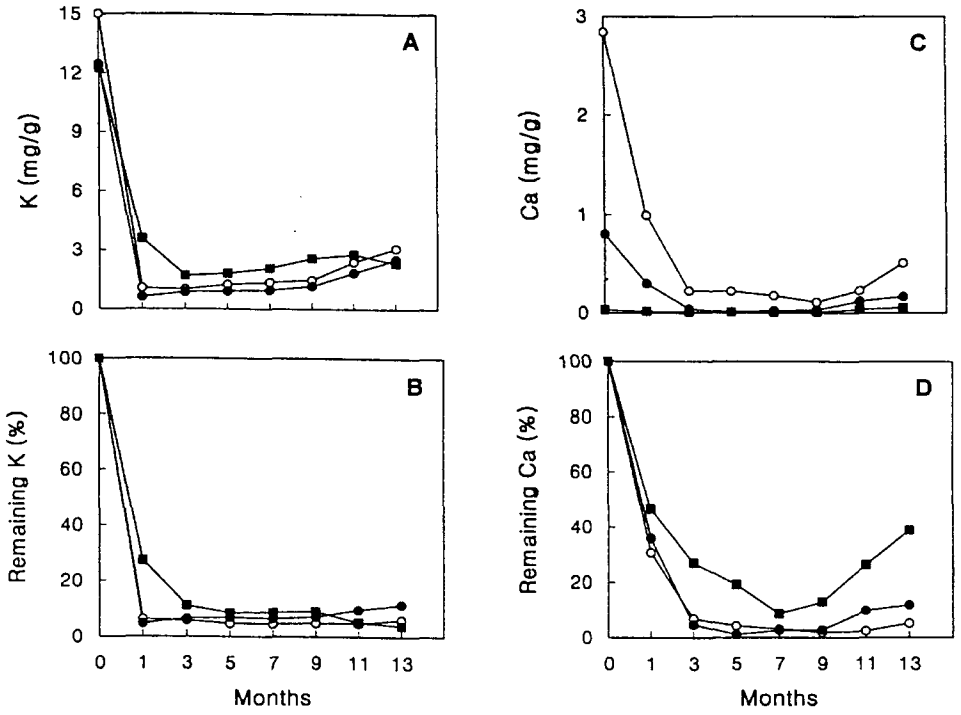


Fig. 3. Changes of K concentration (A), % of remaining K (B), Ca concentration (C) and % of remaining Ca (D) in the decomposing organs of *P. communis*. Legends are the same as in the Fig. 1.

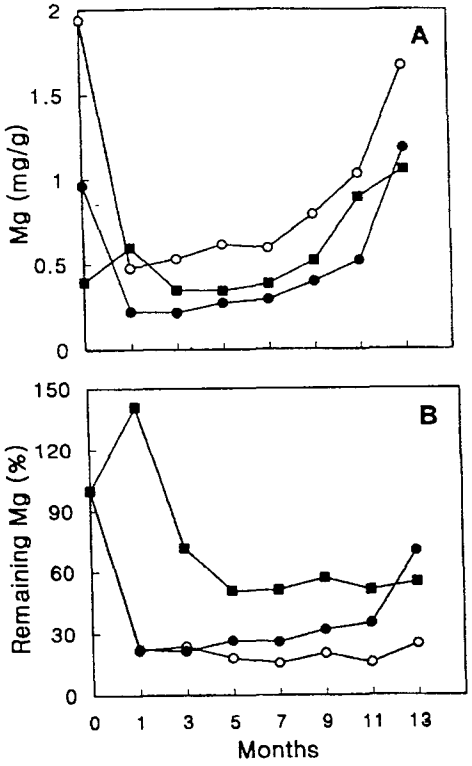


Fig. 4. Changes of Mg concentration (A) and % of remaining Mg (B) in the decomposing organs of *P. communis*. Legends are the same as in the Fig. 1.

rapid loss of K, Mg and phosphorus in emergent hydrophytes takes place within the first month during the decomposition process.

Hammer (1995) suggested that the principal functions of vegetation in wetlands are absorption of nutrients from sediment and creation of additional environments for microbes. However, without any suitable method for removal of dead part after the growing season from the water body, eutrophication of freshwater may be accelerated by decay of dead macrohydrophytes. It is suggested that diverse usage of harvested macrohydrophytes must be developed.

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