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The Purification Capacity of *Zizania latifolia* on Wetlands of Munpyeong Stream

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ABSTRACT: This study examined the changes of water quality in relation to distribution of hydrophytes, and the purification capacity of *Zizania latifolia* to improve the effluent from Munpyeong stream from March 1997 to December 1999. While the concentration of nitrogen and phosphorous in water were increased during the farming season, those decreased, during the streaming down to paddy and drainage areas. In investigated sites, the *Z. latifolia* was dominant community according to the development of the natural wetlands. Furthermore, it formed a large community owing to its high adaptability to environmental changes in the agriculture lands. In September, the leaves productivity of the *Z. latifolia* were 4,032g D.W/m^2 and roots were 7,680gD.W/m^2. The purification capacity of the *Z. latifolia* for NH_3-N, NO_3-N, and PO_4-P were 13.41, 17.07, and 4.58 respectively during 5 days. The results suggested that it needs to establish wetlands vegetated by hydrophytes to improve the water quality of the effluent from agricultural lands.

Key words : Hydrophytes, Purification capacity, Wetlands, *Zizania latifolia*

INTRODUCTION

The water quality of small stream which flow into the Yongsan river is directly affected by the land use (Ihm *et al.* 1996), and the hydrophytes distribution (Kim 1996). The distribution of hydrophytes have direct and indirect influences on the aquatic ecology, and become the habitat of animal and plant plankton, invertebrate animals, and fish as the primary producer of the aquatic ecology (Kaushick and Hynes 1971, Whitton 1975, Vannote 1980, Wetzel 1983, Day, Jr. *et al.* 1989, Nilsson *et al.* 1989). And they have the ability to absorb and purify many organic materials (Lakshman 1979, Minshall *et al.* 1983). The hydrophytes remove BOD and absorb NO_3-N, PO_4-P, inorganic salts (Tripathi *et al.* 1991), cadmium, lead, mercury, copper, phenol and other pollutants, thereby reducing the concentration of water pollutants. They play important roles in protecting water resources (Boyd 1968, Wolverton and McDonald 1979, Reddy *et al.* 1983, Otte *et al.* 1991, Mun *et al.* 2001).

Many studies carried out on the water quality improvement using the hydrophytes in Korea included the elimination of water pollution in raw sewage, cattle sheds, wastewater, and sewage (Kim *et al.* 1991, Kim *et al.* 1998) by use of *Eichhorinia crassipes*. Yongsan River contains a relatively large amount of nitrogen and phosphorus, because living sewage, agricultural drainage, and livestock wastewater flows into river (Shin 1990).

The effluent contains especially rich nutrients during irrigation periods because excessive agricultural chemicals, herbicides, and insecticides are used to increase agricultural production and to prevent damage from harmful insects. On the other hand, the hydrophyte communities in rivers has a purification capacity because the macrohydrophytes absorb many pollutants in polluted water.

Therefore, it is urgently required to preserve the distribution of hydrophytes growing spontaneously in rivers, to understand their purification capacity, and to research in order to improve the water quality of effluent from agricultural land in the Yongsan basin.

The purpose of this study was to examine the hydrophytes which were distributed in the Munoyeong stream and to determine their purification capacity. Also this results will provide basic materials for preserve the natural wetlands of rivers.

MATERIALS AND METHODS

Study area, measurement of water quality and analysis of data

The Munpyung stream was selected for this study because this stream has the typical characteristics of effluent from agriculture lands and the vast areas of wetlands along the left and right sides of the main channel. The length of this stream is 10.6 km and its watershed area is 40.88 km^2. The velocity of current

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water flow was slow as 0.129 m/sec. At this site, the average width of the river is 63m and the width of main water channel are the range from 3m to 10m. The length of the natural wetlands along the stream is about 1.8km(from site 3 to site 4 in Fig. 1), and the HRT(Hydraulic Retention Time) is 1~2 days (except during the rainy season). The annual mean temperature is 12.6℃ and the annual mean precipitation is 1,321mm, but, about 47% of annual precipitation is concentrated in summer(Weather Station of Hampyeong in 1991-1998). Rice planting (1/2 of the whole area) begins in early June and ends in mid-June. Harvesting begins in September at the Dashi plain, including the wetlands for this research.

Water quality was measured at four sites along the river in order to obtain samples of discharge from the agricultural lands (1: upstream, 2: raw sewage, 3: drainage outlet, 4: wetland) from Jan. 1998 to Dec. 1999. The samples were compared in terms of water temperature, pH, conductivity, and salinity, using an water quality auto analyzer (YSI, PC-6000) for indoor measurement, and NH_3-N, NO_3-N and PO_4-P, using HACH, DR-2000 for outdoor measurements. These analyzers produced only an average value after measuring water quality three times for every sample. The correlation matrix was prepared to find out the relationship between different wate⁻ quality parameters in the four sites along the agricultural land stream. SPSS PC$^+$ version 8.0 was used to analyze and interpret the data.

Examination of outdoor vegetation and vegetation table

In this study, the *Z. latifolia* was selected and examined as the representative community of the investigated areas due to its widest distribution. Sampling sites were installed at the survey area and the species within the quadrat and dominance and sociability of each composition species were recorded using the Braun-Blanquet method(1964). Examined data of vegetation determined the unit, based on table operation (Elenberg 1956, Choi 1986, Ohwi 1984, Lee 1990) and a vegetation table was made.

Existing hydrophytes

Leaves and roots of *Z. latifolia* were harvested within the quadrat from April to October 1999 and were dried at 80℃ in the laboratory for 48 hours. Then their dried weight was measured and standing biomass of hydrophytes were compared according to growing period.

Measuring the contents of total nitrogen and phosphorus of plants

The roots and stems of hydrophytes were divided, dried, and crushed by a grinder. They were treated by putting mixed compounds of 4.4ml (Se + $Li_2SO_4 \cdot H_2O$ + H_2SO_4) into a powder sample of 0.4g under weak heat until the initial response occurred. Then this compound was dissolved at high temperature for 2 hours until the solution became transparent. The dissolved solution was cooled and diluted with distilled water, and then total nitrogen was quantified with the Micro-Kjeldahl method (Jackson, 1967), and total phosphorus with Ascorbic Acid method (APHA, 1989).

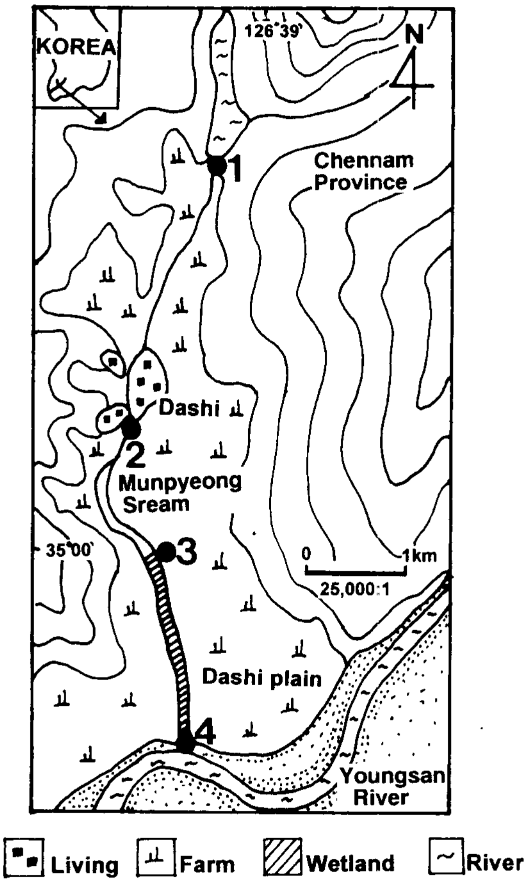

Fig. 1. Map of investigated areas on the agricultural land of the Munpyeong stream in Korea (1:upstream, 2:raw sewage, 3:drainage outlet, 4:wetland).

Measuring purification capacity of water quality by hydrophytes

Plants of uniform size were transplanted without soil in August to four cylindrical indoor purifier tanks (130 liter of capacity), filled with only effluent water from the agricultural land in a density similar to that of the natural condition of the *Z. latifolia* community. Then they were cultured for 5 days, when the purification activity was almost finished. Nitrogen and phosphorus in the purifier tanks were measured at intervals of 24 hours and consequently, the purification capacity of water quality was calculated by the following expression (Tripathi *et al.* 1991).

$C\ (mg.l^{-1}.100g.d^{-1}.wt) = (I - F) / (T \times D)$

C : Purification capacity of plant

I : Initial concentration of plant culture solution
F : Final concentration of plant culture solution
T : Time required for purification
D : Plant dry weight

RESULTS AND DISCUSSION

Characteristics of water quality of effluent from agricultural Land

Water quality at 4 sites was measured from Mar. 1997 to Nov.1998. The average changes in water quality depended on the characteristics of the discharge from the agricultural land (Fig. 2, 3).

NH_3-N ranged from 0.01 to 12.6 mg/l throughout the investigated areas and was 12.6 in early June and 0.10 mg/l in September at the drainage outlet and the difference was relatively high(12.5 mg/l). It ranged from 0.16 to 0.08 mg/l at the upstream area and the difference was relatively low(0.08 mg/l). NH_3-N increased greatly from 3.54 to 12.6 mg/l and from 0.11 to 0.74 mg/l at the wetland and drainage outlet areas respectively, in June and July when rice farming began. However, it was greatly reduced to 9.06 and 0.63 mg/l in the wetlands because of nitrification and absorption by plants. NH_3-N of the drainage outlet and the wetlands was significantly positive in correlation with NO_3-N of the drainage outlet and the wetlands and PO_4-P of the wetland($p < 0.01$) (See Table 1).

NO_3-N ranged from 0.3 to 7.0 mg/l throughout the investigated areas. It was 6.8-7.0 mg/l at the paddy, field, drainage outlet of the agricultural land, wetlands in June and it was higher than that of other investigated areas and during other months. However, while the density change of nutrients was reduced according to the stream from the drainage outlet to wetland flow, NO_3-N increased by 0.2~1.2 mg/l because of nitrification. NO_3-N of the drainage outlet was significantly positive in correlation with that of the wetlands($p < 0.01$). While NO_3-N of the drainage outlet and the wetlands was significantly positive in correlation with PO_4-P of the wetland($p < 0.01$), NO_3-N of living sewage was significantly negative in correlation with pH and salinity upstream($p < 0.01$).

PO_4-P ranged from 0.08 to 3.50 mg/l throughout the investigated areas. It was 2.40 in June and 3.5 mg/l in July at the drainage outlet and was relatively higher than that of other sites. It was 0.28~0.30 mg/l at the upstream area and the difference was relatively low(0.02 mg/l). PO_4-P increased gradually when the fluid flowed into the drainage outlet from the agricultural lands, but decreased at the wetlands. Also, it was relatively high(0.77~0.57 mg/l) at the site where raw sewage flowed into. PO_4-P of the raw sewage was significantly negative in correlation with salinity of the upstream and drainage outlet, Sp. Con. of the drainage outlet, and pH of the living sewage($p < 0.01$). But it had a significantly positive correlation with the upstream water temperature, raw sewage, drainage outlet and wetland($p < 0.01$).

Water temperature ranged from 2.4 to 28.5℃. It was measured from 19.0 to 28.5℃ in June, July, and August. Salinity ranged from 20 to 520 mg/l throughout the investigated areas. While it was 210 mg/l in September and 80 mg/l in August at the drainage outlet, its difference was relatively high(130 mg/l). It was 30~70 mg/l in the upstream area and its difference was relatively low(40 mg/l). Salinity increased gradually when the water flowed into the upstream - inflow spot of raw sewage - paddy fields - drainage outlet of the agricultural land, but decreased greatly at the wetlands(50~260 mg/l). Salinity was significantly positive in correlation with Sp con($p<0.01$), whereas salinity of the upstream, living sewage and the drainage outlet was significantly negative in correlation with the water temperature of the drainage outlet and wetlands($p<0.01$).

pH ranged from 5.9-9.5 throughout the investigated areas. It measured 6.4 in June and 9.5 in March at the drainage outlet, with a high difference (3.1). The pH of the living sewage and upstream was significantly negative in correlation with the water temperature of the drainage outlet($p < 0.01$).

Sp Con. ranged from 0.07-0.93 mS/cm throughout the investigated areas. It measured 0.36 in June and 0.27 mS/cm in September at the drainage outlet, and its variation was relatively low(0.09). Sp Con. was 0.36~0.13 mS/cm in June and July when inflow and outflow of agricultural water in the farmlands occurred at its maximum, and it was high compared with other places and times. However, Sp Con. was far lower at the wetland area than at the drainage outlet. pH at the inflow spot of discharging living sewage was 7.8~6.6 during the same period, and its difference was relatively low(1.2).

In general, the natural wetlands in rivers can be considered a practical alternative for improving the water quality from agricultural lands. Among the four sites of the agricultural land streams, the standard deviation was arose following in the order of drainage outlet > wetland > living sewage > upstream (Table 2). In the drainage outlet, the mean values of NH_3-N, NO_3-N, PO_4-P and salinity were relatively high(1.85, 1.73, 1.06, and 290 mg/l respectively). While the difference between the mean values of NH_3-N and PO_4-P was relatively high, compared to water temperature, pH, Sp conductivity, salinity and NO_3-N.

Distribution and characteristic of Z. *latifolia community*

The Z. *latifolia community* was distributed according to the development of the natural wetlands which was located in a length of 1.8km between the junction of the Yongsan river and the downstream areas of the Munpyung stream. The vegetation is shown in Table 3. Their height of community was 1.8~2.5m, the depth of water was 0.1~1.0m, and the coverage of vegetation was 100%. The mean number of species was 4.2 and the number of individuals per unit area was 112/m^2 in September, and there was a relatively high presence of *Paspalum distichum*

Table 1. Pearson correlation matrix for the water quality parameters of agricultural land. Refer to Fig. 1 for number of sites

		1 : NH$_3$-N (mg/l)				2 : NO$_3$-N (mg/l)				3 : PO$_4$-P (mg/l)				4 : Salinity (mg/l)				5: Sp Conductivity(mS/cm)				6 : pH				7 : Water temperature(˚C)			
	Site	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	1	1.00																											
	2	.01	1.00																										
	3	.22	.52	1.00																									
	4	.36	.47	.98**	1.00																								
2	1	.32	.06	.61*	.59*	1.00																							
	2	.34	.28	.41	.40	.65*	1.00																						
	3	.50	.49	.81**	.85**	.37	.44	1.00																					
	4	.34	.54	.96**	.96**	.61*	.57	.87**	1.00																				
3	1	.56	-.19	-.01	.13	-.02	.12	.45	.13	1.00																			
	2	.52	.08	.30	.41	.03	.41	.50	.47	.54	1.00																		
	3	.26	-.03	.43	.44	.64*	.57*	.27	.52	.18	.39	1.00																	
	4	.65*	.35	.75**	.85**	.44	.27	.80**	.80**	.49	.60*	.46	1.00																
4	1	-.42	-.06	-.44	-.48	-.38	-.74**	-.51	-.61*	-.28	-.73**	-.64*	-.45	1.00															
	2	-.29	.29	-.15	-.20	-.21	-.58*	-.29	-.31	-.34	-.60*	-.49	-.18	.89**	1.00														
	3	-.45	.06	-.17	-.24	-.25	-.69*	-.34	-.37	-.46	-.76**	-.56	-.33	.92**	.87**	1.00													
	4	-.32	.07	-.11	-.16	.04	-.44	-.27	-.27	-.24	-.64*	-.42	-.17	.84**	.85**	.83**	1.00												
5	1	-.39	.04	-.19	-.25	-.17	-.66*	-.31	-.37	-.24	-.69*	-.53	-.25	.90**	.90**	.87**	.91**	1.00											
	2	-.38	-.04	-.22	-.28	-.02	-.51	-.40	-.40	-.27	-.66	-.45	-.30	.88**	.86**	.81**	.95**	.93**	1.00										
	3	-.52	.16	-.07	-.17	-.14	-.55	-.21	-.26	-.37	-.77**	-.51	-.31	.87**	.85**	.94**	.88**	.91**	.85**	1.00									
	4	-.42	.01	-.19	-.25	-.06	-.55	-.36	-.37	-.27	-.69*	-.49	-.27	.90**	.88**	.85**	.97**	.96**	.98**	.89**	1.00								
6	1	-.30	-.13	-.58*	-.61*	-.67*	-.72**	-.44	-.67*	-.22	-.58*	-.59*	-.55	.73**	.57*	.71**	.36	.55	.40	.60*	.43	1.00							
	2	-.42	-.10	-.28	-.33	-.20	-.68*	-.46	-.44	-.36	-.79**	-.52	-.34	.76**	.67*	.77**	.73**	.82**	.71**	.74**	.78**	.50	1.00						
	3	.32	.07	-.262	-.20	-.42	-.58*	-.05	-.30	.06	-.21	-.39	.04	.53	.58*	.51	.27	.44	.27	.36	.28	.73**	.31	1.00					
	4	.27	-.08	-.32	-.27	-.48	-.62*	-.06	-.369	.11	-.22	-.46	-.04	.53	.49	.52	.26	.42	.25	.38	.27	.80**	.31	.96**	1.00				
7	1	.57	-.45	.06	.17	.30	.45	.21	.205	.58*	.75**	.44	.38	-.65*	-.71**	-.76**	-.50	-.64*	-.49	-.77**	-.56	-.64*	-.61*	-.38	-.32	1.00			
	2	.66*	-.34	.16	.29	.38	.47	.34	.313	.67*	.75**	.45	.53	-.65*	-.65*	-.75**	-.43	-.58*	-.45	-.74**	-.51	-.69*	-.57	-.34	-.31	.97**	1.00		
	3	.62*	-.16	.30	.40	.39	.62*	.39	.474	.45	.85**	.59*	.54	-.85**	-.77**	-.86**	-.66*	-.80**	-.69*	-.88**	-.74**	-.76**	-.75**	-.40	-.39	.92**	.91**	1.00	
	4	.65*	-.27	.15	.28	.29	.53	.36	.338	.65*	.85**	.49	.51	-.74**	-.73**	-.83**	-.57*	-.70*	-.59*	-.82**	-.65*	-.67*	-.70*	-.32	-.29	.97**	.97**	.96**	1.00

* Correlation is significant at the 0.05 level.

** Correlation is significant at the 0.01 level.

Table 2. The mean, median, standard deviation, minimum, and maximum values for the water quality of the investigated areas

Sites	NH_3-N (mg/l)				NO_3-N (mg/l)				pH				PO_4-P (mg/l)				4 : Salinity (mg/l)				Sp Conductivity(mS/cm)				Water temperature(°C)			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Mean	0.09	0.43	1.85	0.41	1.09	1.42	1.73	1.91	7.00	7.29	7.23	7.27	0.23	0.46	1.06	0.44	60	140	290	130	0.61	0.24	0.53	0.30	15.17	17.41	15.95	16.35
Median	0.10	0.37	0.89	0.11	1.00	1.05	0.95	1.55	6.85	7.25	6.75	7.00	0.26	0.43	0.74	0.39	80	140	320	140	0.19	0.27	0.58	0.34	16.80	20.65	15.15	18.45
Std. Deviation	0.06	0.28	3.42	0.98	0.38	0.90	1.91	1.64	0.53	0.67	0.97	0.72	0.15	0.22	0.93	0.31	20	70	160	60	0.06	0.11	0.29	0.13	7.18	8.19	8.90	8.00
Minimum	0.01	0.10	0.10	0.01	0.60	0.40	0.30	0.70	5.90	6.50	6.40	6.50	0.08	0.09	0.35	0.09	20	40	60	50	0.07	0.10	0.13	0.11	2.40	3.50	3.50	4.00
Maximum	0.19	1.04	12.60	3.54	1.80	3.10	6.80	7.00	7.60	8.50	9.50	8.80	0.61	0.87	3.50	1.27	100	250	520	260	0.25	0.47	0.93	0.54	25.10	26.60	28.50	28.10

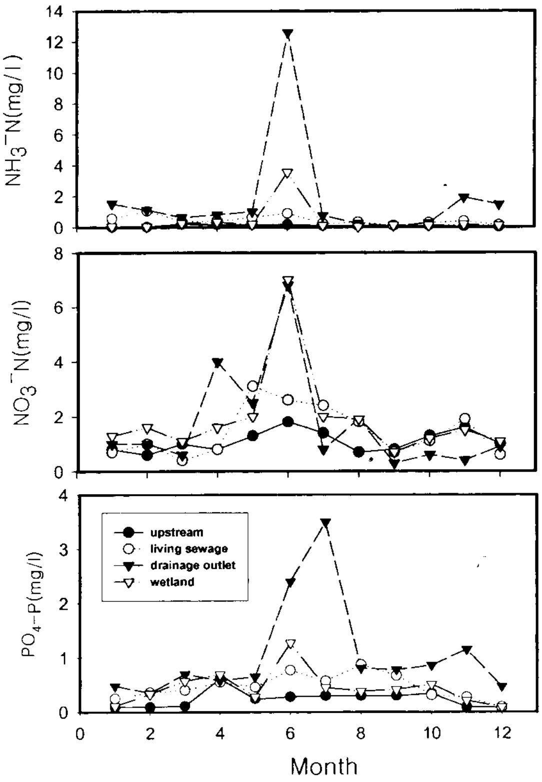

Fig. 2. Water quality (NH_3-N, NO_3-N, PO_4-P) of the investigated areas. Refer to Fig. 1. for number of four sites.

as companions. *Z. latifolia* community is one of the representative purification hydrophytes communities at the Yongsan River and is typically divided into a *Hydrilla verticillata* subcommunity and a *Oenanthe javanica* subcommunity (Kim 1996). It is also divided into a *Phragmites communis* subcommunity and a *Trapa japonica* subcommunity at the wetland area of the Yongsan River and shows the characteristics of the great communities that distributed around small streams which have inflow from agricultural lands. The *Z. latifolia* community of the investigated areas has companions as *P. distichum, Artemisia selengensis, Oenanthe javanica, Echinochloa crus-galli, Actinostemma lobatum, Persicaria thunbergii* and *Persicaria hydropiper* within a 0.4m depth of water and a subcommunity of *Hydrilla verticillata, Ceratophyllum demersum, Myriophyllum verticillatum,* and *Spirldela polyrhiza* within about a 0.8~1.0m depth of water. In case of under a 0.8m depth of water, the development of rhizome was poor, because this depth of water is lower than the nature habitat condition (Table 3). While, the *Typha orientalis, Z. latifolia, Phragmites communis,* and *Scirpus nipponicus* were evaluated for treating industrial wastewater (Lee and Kwak 2000), and the dominant species in the wetlands of the Asan-Lake, Kyonggi-do was *Z. latifolia* (Kim *et al.* 2000). Therefore, the rivers flowing around the agricultural land, shows environmental

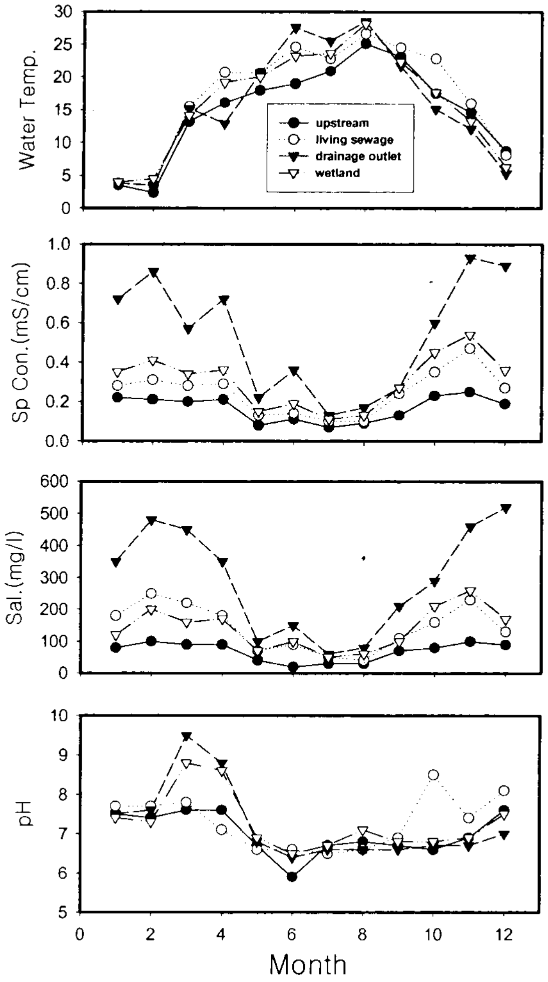

Fig. 3. Water quality (Water Temp., Sal., Sp Con., pH) of the investigated areas. Refer to Fig. 1. for number of four sites.

variation according to the quantity of water and seasonal changes, but *Z. latifolia* forms a large community since it has a high adaptability to environmental changes such as drought and wet.

Productivity of hydrophytes

Z. latifolia makes its community at the edge of rivers or lakes and developes thick, short roots and branching stems in the soil. The productivity of the *Z. latifolia* community, was measured month by month (Fig. 4.). In April when growth begins, the leaves productivity of the *Z. latifolia* were 1,257gD.W./m^2 and the roots were 395gD.W/m^2. In September, leaves were 4,032gD.W/m^2 and roots were 7,680gD.W/m^2. They absorbed a large quantity of nutrients in the soil during the growing period and had direct and indirect influences on the water quality of the rivers. While, annual net production of the hydrophytes was 558.4 ton D.W/yr in the whole Asan-Lake, annual net production of *Z. latifolia* was 227.7 ton D.W/yr (Kim *et al.* 2000). Therefore, the production of *Z. latifolia* is high in the wetlands and one of the major hydrophyte in Korea.

Table 3. Vegetation table of *Z. latifolia* community in the Yongsan River

Serial No.	1	2	3	4	5	6	7
Quadrat size(m)	1	1	1	1	1	1	1
Water depth(m)	0.1	0.2	0.2	0.2	0.4	0.8	1.0
Height of community (m)	2.4	2.5	2.2	1.8	2.5	2.2	1.8
Coverage (%)	100	100	100	100	100	100	100
Number of species	5	4	3	2	5	6	5
Differential species of community							
Zizania latifolia	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Companions							
Paspaium distichum	.	1.1	1.1	1.1	+	.	.
Artemisia selengensis	1.1	1.1	.	.	.	.	.
Spirldela polyrhiza	.	.	.	.	.	1.1	+
Hydrilla verticillata	.	.	.	.	.	2.2	1.1
Ceratophyllum demersum	.	.	.	.	.	1.1	1.1
Myriophyllum verticillatum	.	.	.	.	.	1.1	+
Oenanthe jarnaica	1.1	.	.	.	.	.	.
Echinochloa crus-galli	1.1	.	.	.	.	.	.
Arenaria serpyllifolia	+	.	.	.	.	.	.
Humulus japonicus	.	+	.	.	.	.	.
Actinostemma lobatum	.	.	1.1	.	.	.	.
Erigeron canadensis	.	.	.	.	1.1	.	.
Persicaria hydropiper	.	.	.	.	1.1	.	.
Rumex crispus	.	.	.	.	+	.	.
Ranunculus chinensis	.	.	.	.	.	+	.

+ : appearance of 1 EA.

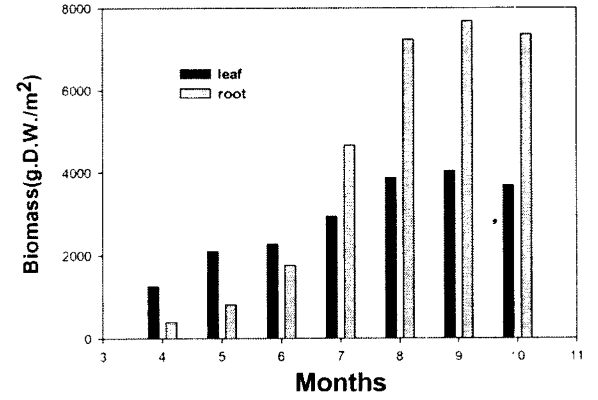

Fig. 4. Biomass of leaf and root of *Z. latifolia* community in the stream of agricultural land.

Total nitrogen and phosphorus of plants

The *Z. latifolia* growing at the sites of effluent from agricultural land were transplanted into the laboratory and cultured for 5 days. They were divided into leaves and roots and then total

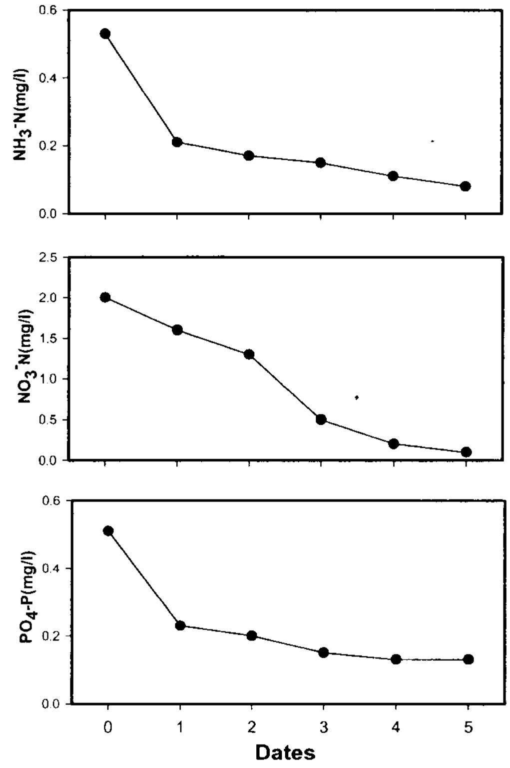

Fig. 5. Changes of water quality (NH_3-N, NO_3-N, PO_4-P) after 5 days culture of *Z. latifolia* in laboratory conditions.

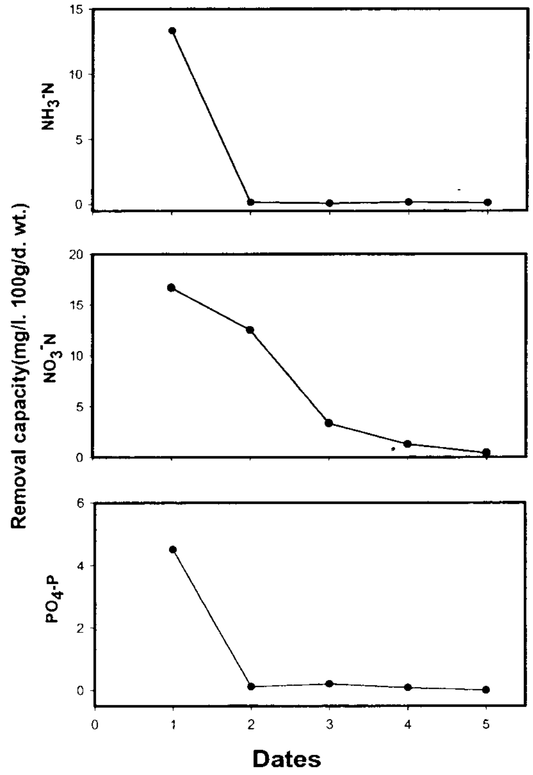

Fig. 6. Removal capacity of NH_3-N, NO_3-N, PO_4-P by *Z. latifolia* after 5 days culture in laboratory conditions.

nitrogen and phosphorus were measured by individually. The total nitrogen contents of the *Z. latifolia* were 25.7 mg/g in leaves and 21.3mg/g in roots. The total phosphorus contents was 4.16 mg/g in leaves and 3.49mg/g in roots. After cultured in the laboratory for 5 days, total nitrogen contents of the *Z. latifolia* were 26.9mg/g in leaves and 22.9mg/g in roots. Total phosphorus contents were 6.84 mg/g in leaves and 5.02mg/g in roots. Accordingly, the absorption of total nitrogen and phosphorus appeared in difference to the leaves and roots of *Z. latifolia*.

Purification capacity of nitrogen and phosphorus by hydrophytes

During the 5-days culture, the changes and purification capacities of nitrogen and phosphorus in the water quality by *Z. latifolia* were measured. After 5 days, NH_3-N was greatly reduced to 0.08 mg/l from 0.53 mg/l NO_3-N reduced to 0.1 mg/l from 2.0 mg/l, and PO_4-P was reduced to 0.14 mg/l from 0.51 mg/l (Fig. 5). The purification capacities for NH_3-N, NO_3-N, and PO_4-P are 13.33-0.08, 16.66-0.41, and 4.50-0.08 $mg.l^{-1}.100g.d^{-1}.wt$, respectively. The purification capacities for nitrogen and phosphorus were highest after 1 day culture (Fig. 6). *Phragmites communis* of Mankyung river showed the highest nitrogen and phosphorus removal capacity for 1.36 and 0.0088 mg $g^{-1}.d^{-1}$.wt (Lee *et al.* 2000)

As a result of the indoor experiment using agricultural drainage, the high purification capacity for nitrogen and phosphorus by *Z. latifolia* was shown, owing to its strong tolerance to environment from the effluent of the agricultural lands. Therefore, rivers with discharge from agricultural land, can be polluted by nutrients, such as nitrogen and phosphorus. However, when such pollutants flow into the Yongsan river, the polluted water will naturally purify at the downstream of the rivers by purification activity of the natural wetlands. This results suggested that natural wetlands can be used for improving the water quality of rivers.

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