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Population Changes of *Suaeda Japonica* in the Saemangeum Reclaimed Land

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새만금 간척지 내 칠면초 개체군의 변화

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국문요약

본 연구는 칠면초의 분포역을 결정짓는 개체수의 변화와 성장 변화를 분석하고자 6개 조사역 18 Site에서 2006～2008년의 3년간 개체수 변화, 지상부길이 생장변화, 토양요인의 변화를 조사하였다. 칠면초의 개체수 변화는 간척으로 인한 해수유입의 급격한 감소가 저위 염습지의 수분공급이 원활하지 못한 환경을 조성하여 2008년도 8월 이후에 급격히 감소하는 영향을 나타냈다. 길이생장변화 역시 강수, 해수유입 감소 등에 의한 탈염이 큰 영향을 미친 것으로 조사되었다. 특히 토양요인의 변화에서 칠면초의 개체수 및 길이생장에 $EC_{1:5}$dS/m가 가장 큰 영향을 미친 것으로 나타났다.

새만금 만경강 하구역 갯벌 염습지는 새만금 간척사업으로 인한 해수유입의 급격한 감소와 담수의 유량변화에 따른 수위변동 등의 환경요인에 의하여 간척사업이전 우점종인 칠면초의 분포역과 생장에 큰 영향을 미쳤다.

Key Words : *개체수변화, 길이생장변화, 전기전도도, 토양요인변화, 해수유입감소*

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I. Introduction

A land of 40,100 ha was created by the 'Saemangeum Land Reclamation Project' initiated in the administrative areas of Gunsan and Gimje cities and Buan-gun in Jeonbuk Province, Korea that also encompass Mangyeong and Dongjin River estuaries, Sinsi and Yami Islands of Gogunsan Archipelago, as well as Osik and Bieung Islands in the Outer Marine District of the Geum River. The Reclamation Project began in 1991 and ended up with constructing a 33km sea dike with fresh water damming started from April 2006 (http : //www.isaemangeum.co.kr).

An obvious variation has been observed in the horizon and species composition of vegetation following desalination as time goes on after the reclamation work of tidal flat in this area was finished. Salt plants were dominant in the beginning but ebbed away slowly, leaving a cluster in parts of the region where changes took place in vegetation because of neutral plants that invaded in the reclaimed land.

Studies on reclaimed lands have been carried out mainly by scholars of the Netherlands who have played a central role in this area. Feekes (1936, 1943), Zuur (1961) and Van der Toorn *et al.* (1969), all from the country, have made surveys of changes in soil and developments of vegetation after reclamation (Min, 1985). Besides, Joenje (1979) focused his attention on variation of soil environment and emergence of species after reclamation while Gray (1974, 1977) concentrated upon the issues of ecological succession and desalination of soil in the reclaimed lands.

In Korea, studies on reclaimed lands included those by Min and Kim (1983), as well as by Rye and Kim (1985) who made researches on the productivity of vegetation, circulation of salt water and energy flow in the reclaimed lands. Ihm and Lee (1998) studied the relationship between plant communities and soil factors in the wetland along the West Coast whereas the studies by Lee (1989) and Kim *et al.* (2005, 2006) centered around salt plant or halophyte in the areas of Mangyeong and Dongjin rivers which are parts of Saemangeum Reclaimed Land.

Generally, a colony of salt plants remains as minority due to high grade of salt on the soil and a peculiar zonation is formed out of it depending on the local environmental factors such as slope of land, salt content in soil, duration and frequency of seawater flooding, soil texture, underwater level, etc. The change in horizon and growth after reclamation of *Suaeda japonica* dominant not only in the Saemangeum land but also in most salt marshes of Korea is regarded as an important indicator to determine any variation in vegetation of the reclaimed land. The reason is that because *Suaeda japonica* used to yield an advantageous growth pattern in which it easily settles down under the frequent slope of tidal level in the salt marsh of low grade, decreased flow of seawater following the reclamation in Saemangeum will no doubt exercise a severe impact on survival of *Suaeda japonica.*

The present study is concerning the salt marsh formed in the estuary of Mangyeong and Dongjin rivers which was far wider and broader than now before the dike of Saemangeum Reclaimed Land was built. Until before completion of the dike, *Suaeda japonica* was predominant in this salt marsh. Since the sea level started to be adjusted after completion of the dike, there have been drastic changes in vegetation of the salt marsh.

Besides *Suaeda japonica* being predominant species, there were also a few salt plants like *Suaeda asparagoides*, *Suaeda maritima,* etc. in the area before the land reclamation project embarked. As the generic character becomes variant due to desalination of soil following the reclamation, which greatly affects distribution of *Suaeda japonica,* predominant species in the area, attempts have been made to presume the successional trends in the reclaimed land through analyses into variation of vegetation following desalination.

The objective of the present study is, thus, to suggest measures to preserve and restore vegetation in salt marsh and to create, maintain and manage salt marsh as well as to provide fundamental data required to find out the ecological succession mechanism of vegetation in a reclaimed land by monitoring the range and change of *Suaeda japonica* that is widely distributed in seaside salt marsh in the Mangyeong River estuary.

II. Contents and Methods of Investigation

1. Situation of the area to be investigated

Six areas selected as subjects for this study were tidal areas of river basins at Kyungchang in Daeya-myeon, Jeungseok in Hoehyeon-myeon Eoeun in Okku-eup, Manghaesa Temple, Jinbong in Jinbong-myeon and Hwapo, Mangyeong-eup (Figure 1). Field surveys were conducted from May to October from 2006 to 2008.

2. Water level condition

The traits of water level condition are that average water level in the growing period of halophytes was similar to annual average water level, annual low level and high level appeared in the growing period, and water level was usually maintained within a range of -1.0m～+0.5m above mean sea level, but it has changed more frequently year by year (Figure 2).

Figure 1. A map showing the study areas (**S.1** : Eoeun (N35°53′31.7″, E126°40′37.20″), **S.2** : Jeungseok (N35°53′26.78″, E126°46′4.08″), **S.3** : Kyungchang (N35°54′26.13″, 126°48′ 25.10″, **S.4** : Jinbong (N35°51′6.72″ E126° 41′45.61″), **S.5** : Manghaesa (N35°51′38.16″, E126°43′10.63″), **S. 6** : Hwapo (N35°53′6.30″, E126°47′51.64″).

3. Method of investigation

In order to determine the change in population of *Suaeda japonica* and growth of its length in aerial parts caused by increased fresh water influx and decreased seawater influx through the lock gate following completion of the Saemangeum Reclamation Project, the growth of the population and length in ground parts of *Suaeda japonica* were measured by means of quadrates in size of 1m×1m fixed in 2006 at the coverage of *Suaeda japonica* with 80% (S.1), with lower than 10% (S.2) and with none or minor population (S.3), respectively, on the basis of low tidal level set forth before damming.

The survey of the soil environment was conducted with a view to explore the influence of change in EC following less influx of seawater upon distribution of *Suaeda japonica*.

For the purpose of analysis, collected soil was dried in the shade and filtered by means of a sieve with meshes of 2mm. The soil powder

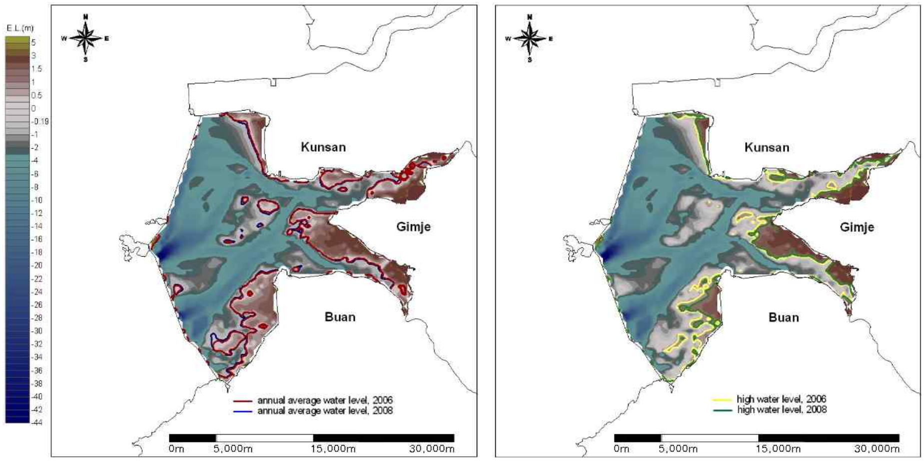

Figure 2. Average water level and high water level, 2006 and 2008.

acquired thereby was used for an experiment sample. Particle size analyser (hydrometer method) and soil pH (glassmicroelectrode method) were used for analysis. In addition, the soil analysis of the Rural Development Administration (2000) was employed to find EC and Walkley & Black method of SSSA (Soil Science Society of America) was applied to determine the contents of organism.

III. Results and Discussion

Since *Suaeda japonica* owns an advantageous growth pattern in which it easily settles down under the environment with sufficient supply of water and frequent slope of tidal level in the salt marsh of low grade, drastically decreased influx of seawater following reclamation in Saemangeum had a great influence on horizon and growth of *Suaeda japonica*.

Changes in the population and growth of *Suaeda japonica* were revealed as follows from the analysis into the research on 18 sites in 6 areas for 3 years from 2006 to 2008 which was intended to monitor the influences of the Saemangeum Reclamation Project on environmental factors like rapid decrease of seawater influx, change of fresh water flow in the salt marsh of tidal flat in Mangyeong River.

1. Change of population

The number of population of *Suaeda japonica* in 18 sites of 6 areas studied has changed greatly depending on the sites investigated (Figure 3). Since *Suaeda japonica* is inclined to show a growth pattern favorable for settling down in the environment[6] where there is frequent slope of tidal level in the salt marsh of low grade and sufficient water is supplied, the population of *Suaeda japonica* has dropped down drastically since August 2008 when the salt marsh at low gradient was not flooded any more, which resulted in sudden decrease of seawater influx, following completion of the Saemangeum Reclamation Project.

The population of *Suaeda japonica* decreased significantly at the site 1 of each area where it was relatively dominant. Such change of vegetation in this area is mostly attributed to the change in its physical environment due to seawater flow blocked by the reclamation bank.

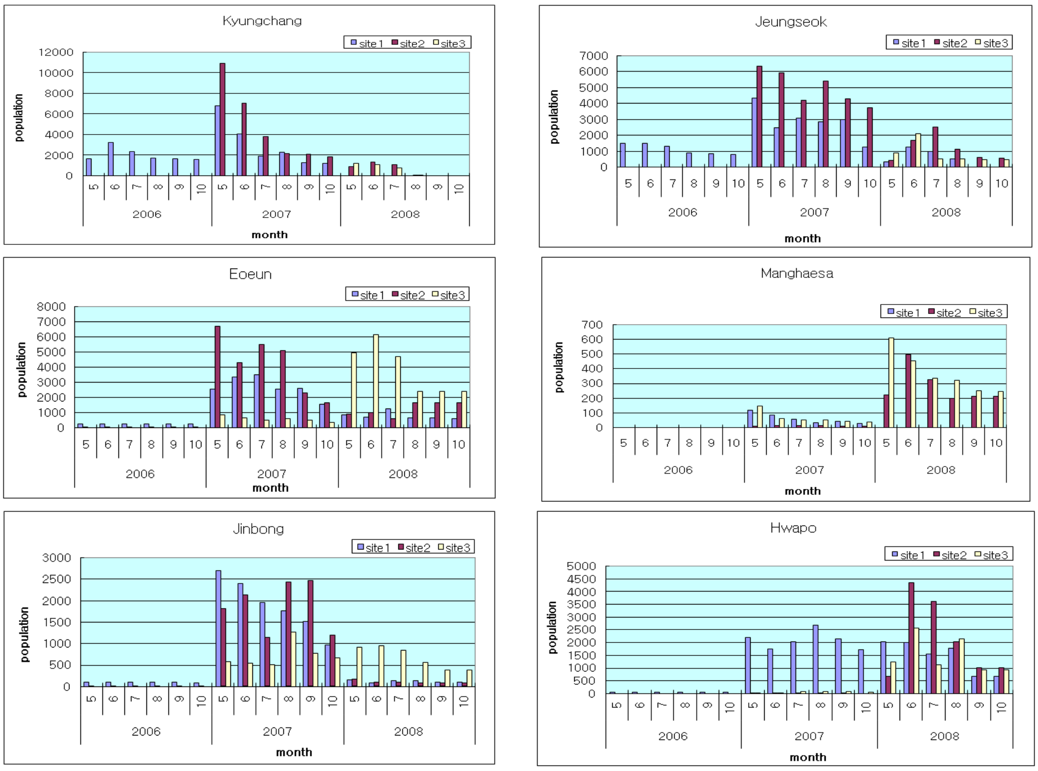

Figure 3. Comparison of population by sites surveyed in 2006, 2007 and 2008.

Before damming works started, there was no severe mid-level competition at the low- and mid-gradient of salt marshes since *Suaeda japonica* put out buds about 1～2 months earlier than *Suaeda asparagoides*. After the damming, however, *Suaeda asparagoides* began sprouting early, leading to competition with *Suaeda japonica* whose population was thus reduced. *Suaeda asparagoides* seemed to have advantage over *Suaeda japonica* in its mid-level competition with the latter owing to its quasi-simultaneous germination type of characters which cause simultaneous sprouting when surrounding conditions are felt efficacious for it.

2. Change in the length of aerial parts

Figure 4 shows the results of change in growth of *Suaeda japonica* in length at 18 sites in 6 areas during 3 years from 2006 through 2008.

In case of Kyunchang, one of the sites surveyed, no *Suaeda japonica* appeared at the coverage of *Suaeda japonica* with 80% during 2008, while its growth in length of aerial parts decreased at the coverage of *Suaeda japonica* with lower than 10%. In Jeungseok, no big difference was confirmed in its growth at site 1 during the years 2006～2007 but fairly good growth in its length could be observed until August 2008, ending only in blight according to the survey conducted in September of the same year. In 2008, the 3rd year since it began to monitor the change of growth in its length, big decrease was reported in 2008 compared to 2007.

Some increase in growth of *Suaeda japonica* in

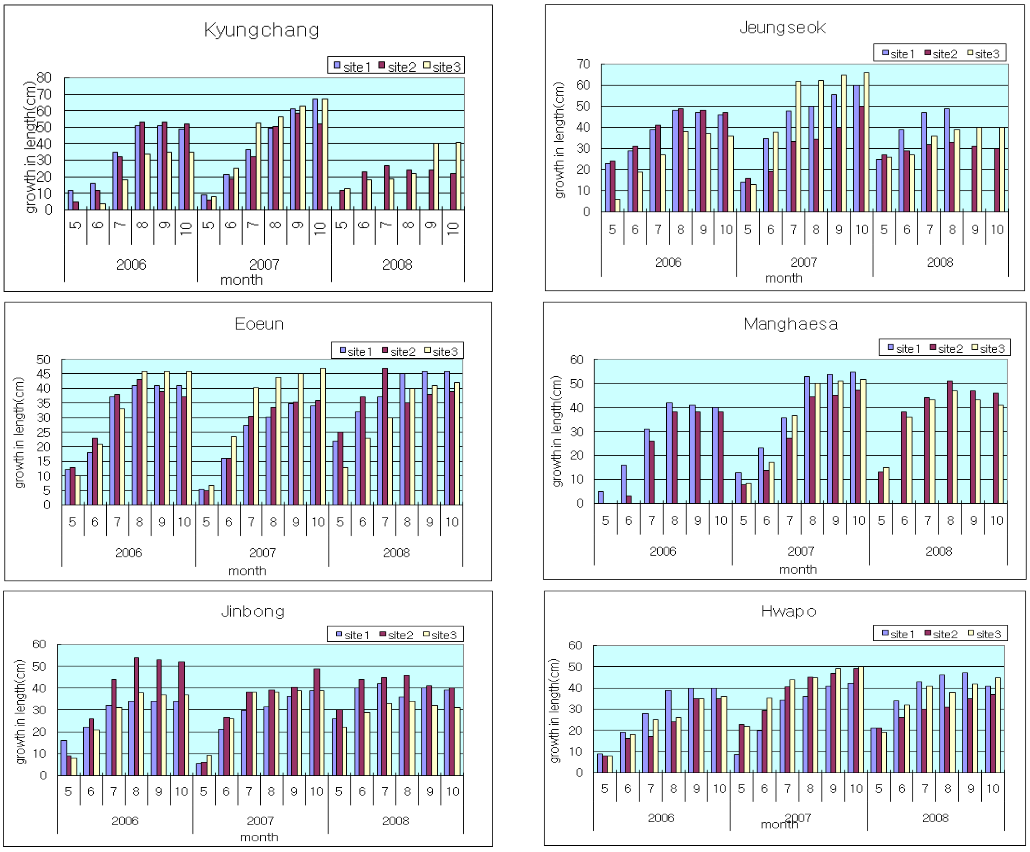

Figure 4. Comparison of growth in length by sites surveyed in 2006, 2007 and 2008.

length was experienced at the coverage of *Suaeda japonica* with 80% in Eoeun-ri but no change at the coverage of *Suaeda japonica* with lower than 10% and none or minor population. At the coverage of *Suaeda japonica* with 80% of Manghaesa region, *Suaeda japonicas* were found to have withered completely according to the survey in 2008 while at the coverage of *Suaeda japonica* with none of minor population, where not a *Suaeda japonica* existed in 2006, it appeared and featured a good growth in length in 2007 and 2008, confirming obvious change in horizon of *Suaeda japonica.*

Jinbong (S.4) saw no big annual differences in growth of *Suaeda japonicas* but some between May and June. In Hwapo, however, the most flourishing growth of *Suaeda japonica* was found at the coverage of *Suaeda japonica* with 80% in 2008 but, to the contrary, some decrease was experienced at the coverage of *Suaeda japonica* with lower than 10% and none or minor population.

As a consequence, growth in ground parts of *Suaeda japonica* was not satisfactory at the coverage of *Suaeda japonica* with lower than 10% and none or minor population. of each area in the years 2007 and 2008 when seawater influx suddenly started to decrease, compared to 2006.

The strategy of *Suaeda japonica* to survive and apply itself to the process of transformation from low gradient salt marsh to mid- or high-gradient one is believed to explain such phenomenon including change in length of aerial parts as it has usually grown in low-gradient salt marsh which began desalinization after dam construction work started.

3. Change of soil component

The Table 1 show the physical as well as chemical changes of soil in 18 sites of the surveyed 6 areas. According to the survey, the soil of the land reclaimed after damming of the Saemangeum Reclaimed Land in 2006 turned out to have prevalent composition of SiL, with $pH_{1:5}$ of 5.9～8.3. $EC_{1:5}$dS/m was found to have increased much more in Manghaesa Temple, Hwapo and Jinbong areas than in any other ones. In 2007, there was little change in soil composition while soil acidity decreased in Hwapo area and $EC_{1:5}$dS/m became lower in all areas surveyed in comparison to 2006. In 2008, however, SiL was discovered to be dominant in all areas with $EC_{1:5}$dS/m decreased drastically although $pH_{1:5}$ remained at 6.2～7.7 without big difference in most areas.

The survey revealed a huge difference in the number of population and the length in aerial parts of *Suaeda japonica* in parallel with the changes in soil composition (Figur 3 and Figur 4).

Table 1. Soil component in 18 sites of 6 areas studied in the Saemangeum reclaimed land in 2006～2008.

Soil component \ Aear / Site / Year		Manghaesa			Jinbong			Jeungseok			Eoeun			Hwapo			Kyungchang		
		st.1	st.2	st.3	st.1	st.2	st.3	st.1	st.2	st.3	st.1	st.2	st.3	st.1	st.2	st.3	st.1	st.2	st.3
Sand(%)	2006	19.0	68.0	66.0	69.0	17.0	23.0	18.0	23.0	39.0	89.0	20.0	23.0	39.0	21.0	29.0	17.0	20.0	23.0
	2007	30.0	70.0	76.0	68.0	40.0	30.0	15.0	23.0	26.0	14.0	12.0	14.0	25.0	22.0	23.0	9.5	10.5	13.5
	2008	29.0	18.0	20.0	19.0	22.0	19.0	16.0	23.0	26.0	14.0	12.0	15.0	13.0	13.0	12.0	9.0	10.0	13.0
Silt(%)	2006	73.0.	28.0	29.0	29.0	75.0	73.0	76.0	73.0	55.0	5.0	75.7	73.0	55.0	73.0	65.0	81.2	75.5	72
	2007	63.0	28.0	18.0	30.0	56.0	62.0	77.5	73.0	70.0	78.5	78.0	78.0	68.0	72.0	34.0	81.5	80.5	79.0
	2008	66.0	75.0	72.0	77.0	73.0	76.0	77.0	73.0	69.0	78.0	78.0	77.0	76.0	77.0	79.0	82.0	81.0	80.0
Clay(%)	2006	8.0	4.0	5.0	2.0	8.0	4.0	6.0	4.0	6.0	6.0	4.3	4.0	6.0	6.0	6.0	6.5	4.5	5.0
	2007	7.0	2.0	6.0	2.0	4.0	8.0	7.5	4.0	4.0	7.5	10.0	8.0	7.0	6.0	2.0	9.0	9.0	7.5
	2008	5.0	7.0	8.0	4.0	5.0	5.0	7.0	4.0	5.0	8.0	10.0	8.0	11.0	10.0	9.0	9.0	9.0	7.0
$pH_{1:5}$	2006	8.3	7.0	7.6	7.8	7.0	7.5	6.2	6.0	6.5	6.7	8.0	7.5	7.2	6.6	6.8	5.9	6.2	6.1
	2007	5.5	6.9	6.1	5.5	6.6	5.5	6.7	7.1	6.9	7.2	6.2	7.3	7.5	5.2	5.3	6.9	7.0	6.4
	2008	6.8	7.1	6.1	7.3	7.7	6.9	6.4	6.3	6.4	7.2	6.2	6.2	7.6	7.6	7.6	7.0	6.4	6.0
Organic matter(%)	2006	0.59	0.36	0.52	0.26	0.78	0.59	0.94	0.59	0.44	0.47	0.30	1.00	0.44	0.55	0.48	0.30	0.15	0.25
	2007	0.32	0.50	0.75	0.22	0.35	0.48	0.18	0.35	0.55	0.38	0.15	0.75	0.45	0.38	0.22	0.68	0.68	0.62
	2008	0.98	0.81	0.74	0.32	0.37	0.39	0.77	0.33	0.38	1.23	1.23	0.73	0.77	0.91	0.90	1.10	1.02	0.65
$EC_{1:5}$ (dS/m)	2006	4.89	9.59	8.06	7.38	7.54	6.45	5.55	5.37	4.46	3.58	6.42	6.00	7.58	7.30	8.23	6.42	5.87	5.30
	2007	2.76	6.43	3.54	2.87	2.84	3.03	1.31	0.72	2.28	2.08	1.49	2.32	1.14	6.45	5.76	1.35	1.21	2.75
	2008	0.66	1.32	3.64	2.46	1.43	2.86	0.94	1.74	1.83	0.66	1.48	1.21	1.36	1.48	1.65	0.69	0.77	2.16

Since there was virtually no big difference in soil environment in 2006 compared to that before damming when sea water flowed smoothly, $EC_{1:5}$dS/m seemed to get higher than the year 2007～2008, bringing the number of individuals to lower ond or inhibiting germination of *Suaeda japonica* completely. The huge decrease in the number of its population in Kyungchang, Jeungseok and Jinbong areas is believed to be the result of competition with *Aster tripolium*, *Atriplex gmelinii*, *Chenopodium virgatum*, *Calamagrostis pseudo-phragmites* and *Sonchus brachyotus* that flourish particularly in places in which land plants are less infiltrated, soil is desalinized and $EC_{1:5}$dS/m is low.

As most plants grow well in the range of $pH_{1:5}$ 4～9 (Arron and Johnson, 1942; Small, 1946), $pH_{1:5}$ 5.2～8.3 of the surveyed areas couldn't exercise any big impact upon their number of population and growth, Whereas, however, relation between $EC_{1:5}$dS/m and *Suaeda japonica* indicated that $EC_{1:5}$dS/m has affected the change in factors of soil environment following less influx of sea water.

Ⅳ. Conclusion

There was a quite big change in the number of population and growth in length in aerial parts of *Suaeda japonica* depending on site among 18 sites in 6 areas.

Since *Suaeda japonica* owns an advantageous growth pattern in which it easily settles down under the environment with sufficient supply of water and frequent slope of tidal level in the salt marsh of low grade drastically decreased influx of seawater following reclamation in Saemangeum had a severe influence on horizon and growth of *Suaeda japonica*. Especially at site 2 where *Suaeda japonica* are not exist until before completion of the Saemangeum project, it became more dominant following the reclamation work that caused less influx of seawater and decreased supply of water in salt marsh at lower plane. Both physical and chemical change of soil by desalination after rain or so has exercised immense impact on the growth of *Suaeda japonica*, leading to a vivid transformation of horizon and overall vegetation as well.

As the change in vegetation of *Suaeda japonica* stock is defined by distribution of stock that relies on sprouting and settlement of seeds, sudden reduction in seawater influx after reclamation in Samangeum, subsequent change of environment at low tidal level without variation due to repetition of flooding and drying as well as increase of freshwater influx have direct influence on the wedge of waterways in mud flat, showing an obvious tendency that the distribution of *Suaeda japonica* population moves toward seashore which waterways neighbor with. Such change in the horizon of *Suaeda japonica* as this has caused to change its population and growth, prompting rapid succession of vegetation in the reclaimed land.

Especially before damming works started, there was no severe mid-level competition at the low- and mid-gradient of salt marshes since *Suaeda japonica* put out buds about 1～2 months earlier than *Suaeda asparagoides*. After the damming, however, *Suaeda asparagoides* began sprouting early, leading to competition with *Suaeda japonica* whose population was thus reduced. *Suaeda asparagoides* seemed to have advantage over *Suaeda japonica* in its mid-level competition with the latter owing to its quasi-simultaneous germination type of characters which cause simultaneous sprouting when surrounding conditions are felt efficacious for it.

The strategy of *Suaeda japonica* to survive and apply itself to the process of transformation from low gradient salt marsh to mid- or high-gradient one is believed to explain such phenomenon including change in length of aerial parts as it has usually grown in low-gradient salt marsh which began desalinization after damming works started.

Specially, the survey of the relation between $EC_{1:5}$dS/m and *Suaeda japonica* indicated that $EC_{1:5}$dS/m has affected the change in factors of soil environment following less influx of sea water.

LITERATURE CITED

Arron, D. T., and C. N. Johnson. 1942. Influence of hydrogen in concentration on the growth of hijher plants under controlled conditions. Plant Physiol. 17 : 525-539.

Buttery, B. R., and J. M. Lambert. 1965. Competition between *Glyceria maxima* and *Phragmites communis* in the region of Surlingham Broad. I. The competition mechanism. J. Ecol. 53 : 163-181.

Feeks. W. 1936. De ontwikkelig van de natuurlijk vegetatie in de wierigermeer poleder de naturlijke eerste groote droogmakerij van de Zuiderzee. Ned. Kruidk. Arch. 46 : 1-295 (Refer to Reimold and Queen, 1974).

Feeks. W. 1943. De Piamer kooiwaard en Makkumerwaard. Ned. kruidk. Arch. 53 : 288-330 (Reger to Reimold and Queen, 1974).

Grace, J. G., and R. G. Wetzel. 1981. Habitat partitioning and competitive displacement in Cattails (Typha) experimental field studies. Amer. Nat. 118 : 463-474.

Gray, A. J. 1974. The genecology of salt marsh plants. Hydro. Bull. 8 : 1452-165.

Gray, A. J. 1977. Reclaimed Land. In The coastline, R. S. K. Barnes ed., John Wiley & Sons, London. pp.253-270.

Harper, J. L. 1977. The population biology of plants. Academic Press, London. pp.684-694.

Ihm B. S., and Lee J. S. 1998. Soil Factors Affecting the Plant Communities of Wetland on Southwestern Coast of Korea. Korean J. Ecology, 21(4) : 321-328.

Joenje, W. 1979. Plant succession and nature conservation of newly embanked tidal flats in the Lauwerszeepolder. in Ecological processes in coastal environments, R. L. Jefferies and A. J. Davy eds. pp.617-634.

Kim C. H., Lee K. B., Cho D. S., and Myoung H., 2006, The Study on the Flora and Vegetation of Salt Marshes of Mankyeong River Estuary in Jeonbuk. korean J. Env. Eco. 20(3) : 289-298.

Kim C. H., Lee K. B., Kim J. D., Cho T. D., and Kim S. M. 2005. The Study of the Flora and Vegetation of Salt Marshes of Dongjin-river Estuary in Jeonbuk.

Kim C. H. 2009. Stuies on Vegetation for Ecological Restoration of Salt Marshes in Saemangeum Reclaimed Land -Population Formation Strategies of Halophytes-. Journal of the Environmental Sciences, 18(4) : 463-471.

Kim C. S., and Song T. G. 1983. Ecological Studies on the Halophyte Communities at Western and Southern Coasts in Korea. The Ecological Soviety of Korea, 6 : 167-176.

Lee J. S. 1989. On establishment of halophyes along tidal level gradient at salt marshes of Mankyung and Dongjin River estuaries. Seoul National Univ. Ph.D. Thesis.

Lee M. W. 2001. Distibution of halophytes along the gradients of soil environments in the coastal saltmarshes of Yellow Sea, Korea, Inha University. Master's Degree thests. 24.

Mark, R. N., and J. L. Harper. 1977. Interference in dune annulas, spatial pattern and neighbourhood, J. Ecol., 65 : 345-363.

Min. B. M. 1985. Changes of Soil and Vegetation in Coastal Reclaimed Lands, West Coast of korea, Ph. D. Dissertation. Seoul National university.

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

Ryu, B. T., and Kim, J. H. 1985. Comparison of estimation methods for primary met production at herbaceous coastal march vegetation. Korean J. Ecol. 8(3) : 133-140.

Misra, R D. 1938. Edaphic factors in the distribution of aquatic plants in the English lakes, J. Ecol. 38 : 441-451.

Sin M. H., and Kim C. H. 2010. Traits of water level control by sluice gate and halophyte community formation in Saemangeum. The Ecological Soviety of Korea (in press).

Small, J. 1946. pH and plants. Van. Nostrand Co. New York. pp.216.

Van der Toorn, J., M. Brandsma, W. B. Bates and M. G. Penny. 1969. De Vegetatie van Zuidelijk Flevoland in 1968. De levende Natuur. 72 : 56-51.

Zuur, A. J. 1961. Initicle bodemborming bij mariene gronden. Me. van Laudbouwhogeschool en de opzoekingsstations van de Staa te Gent, 24 : 7-33.

http : //www.isaemangeum.co.kr