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Soil Texture and Desalination after Land Reclamation on the West Coast of Korea

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西海岸 干拓地 土壤의 土性과 脫鹽

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ABSTRACT

From 1984 to 1989 reclaimed coastal lands in Choongnam Province of the western coast of Korea were studied for soil texture at three sites(Daeho, Hyundai A and Hyundai B) and for desalination one site(Hyundai B). The soil textures of varied sites in Hyundai A were horizontally similar and composed of 39~40% clay, 40~49% silt and 8~14% sand. But those in Daeho and Hyundai B differed horizontally in the same area and vertically at the same site. Soil texures of Daeho were composed of 15~17% clay, 30~45% silt and 40~55% sand and those of Hyundai B were composed of 22~45% clay, 26~49% silt and 17~31% sand. The measured electrical conductivity(EC), which represents whole salt content of the reclaimed soil, decreased year by year. The vertical distribution of the EC changed temporally and spatially in the upper zone above a 50 cm depth but not in The lower zone below a 50 cm depth. The EC values of the soil were inversely proportional to the magnitued of annual precipitation, evaporation and the numbers of rainy days with r equalling −0.97. But the annual decrease of the EC was directly proportional to climatic factors with r=0.7. Salt in the reclaimed land was leached out by the percolative action of surplus rain water, or moved up by evaporation and carried away by running rain water. The running out of the salt on the soil surface was most efficiently carried out over 10 mm precipitation per day.

Key words: Soil texture, Desalination, Reclaimed soil, Precipitation, Coast, Climatic factor, Electric conductivity.

INTRODUCTION

There are broad areas of intertidal flats comprising 2,827 km² on the southern and western coasts of Korea(Bartz 1972). These tidal flats are generally classified into three zones: high-tidal, mid-tidal and low tidal(Lee *et al.* 1985, Park 1987). The combination of large tidal ranges, strong tidal currents and strong wind driven currents make for a dynamic environment on these coasts(Choi 1980). The intertidal flats have been embanked or are being embanked by reclamation projects for farmland, housing and industrial complexes so it they have been abruptly reduced in area.

The salts in the soil are leached away by rainwater so they are reduced year by year under the this natural condition(Chang *et al.* 1978). In coastal reclaimed land the faster the sediment is desalinated the sooner crops can be cultivated. After reclamation, sediment becomes the common soil, vegetation invades it and grows vigorously until land use.

Soil chemical properties after reclamation in coastal area have been studied by many workers of the Netherlands(Feeks 1943, Zuur 1961, van der Toorn *et al.* 1969) and Britain(Beeftink 1975, Gray 1977), but studies on the soil of reclaimed land in Korea are scant.

The purpose of this study was to identify the changes of soil properties after reclamation on the western coast of Korea with special reference to the relationships between desalination and climatic factors for a time period of 6 years.

STUDY AREA

This study was conducted at 3 reclaimed land areas located in the western coast of Choongnam, Korea(Fig. 1). Solis for the study of soil texture were sampled from reclaimed lands of Daeho embanked in 1984 in Galorim Bay(36° 59′ N, 126° 28′), and Hyundai A embankd in 1984 and Hyundai B in 1982

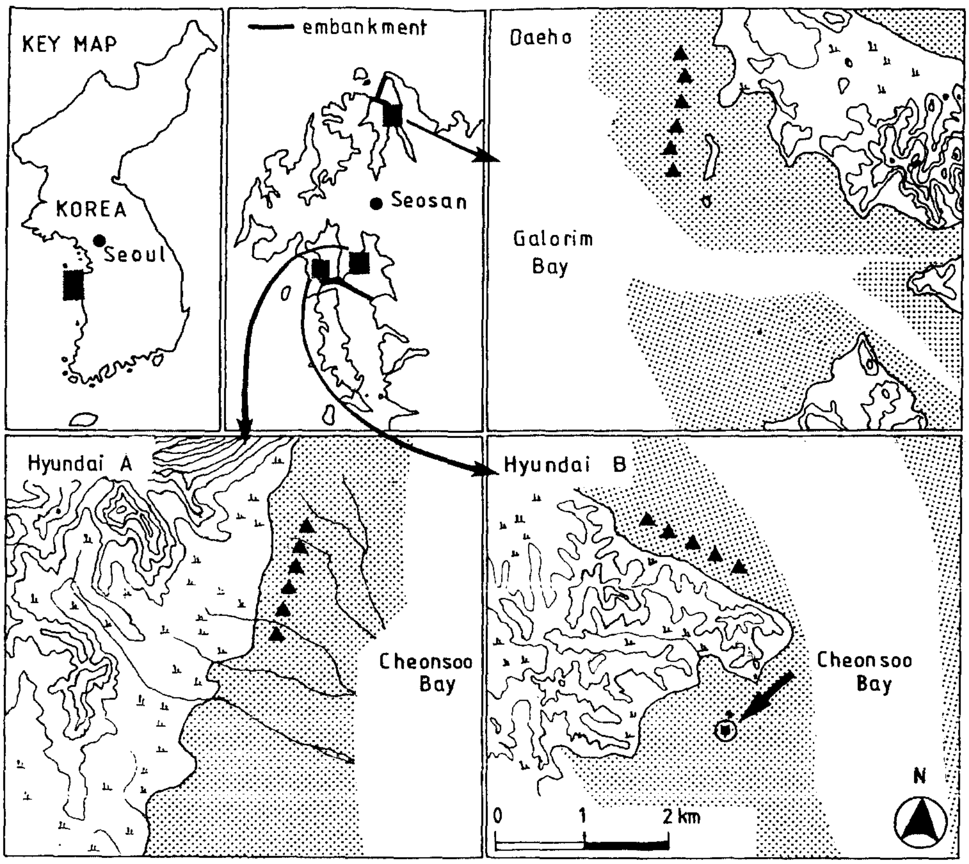


Fig. 1. Map showing the study areas.
▲ : Sampling sites for soil texture analysis
◉ : Sampling sites for desalination
▦ : High tidal flats within reclaimed land

in Chonsoo Bay(36° 37′ N, 126° 20′ E). Soil for the study of desalination was sampled only from the reclaimed land of Hyundai B from 1984 to 1989, most of this reclaimed land has been cultivated as rice paddies since 1990. These three reclaimed lands sampled their correspond to high tidal flats and adjoin a brackish water reservoir at their lower sides. On the high tidal flat rainwater and surface runoff flow into the reservoir along with brackish water through creeks and then is pumped out to sea. A low tidal flat is often inundated by seawater through the leakey bank, while a high tidal flat in not influenced by seawater except during spring flood tides. Human inpact affecting soil desalination was not established during the sampling period.

Climatic data used for this study are from the datqa base at Seosan Meteorological Station(36° 47′ N, 126° 27′ E), located 17 km NE from the reclaimed land of Hyundai B, which showed 11.6℃ as the annual mean temperature and 1,216 mm of annual mean precipitation from 1968 to 1990.

MATERIALS AND METHODS

Annual precipitation, annual evaporation, the numbers of annual rainy day and rainy days were classified according to 3 levels of rain intensity, over 5 mm, over 10 mm and over 20 mm per day, according to data from Seosan Meterological Station.

Soil texture samples were taken from 6 sites at intervals of approximately 200 m in the reclaimed land of Daeho and Hyundai A from July to August in 1986. Desalination samples were done at 2 to 3 sites within 20 m in diameter in Hyundai B in July from 1984 to 1989(Fig. 1). Attention was paid to the selected soil sampling sites which would not be disturbed or affected by humans or by seawater. Vertical soil sampling was carried out at intervals of 5 cm from the top to 1 m in depth or to the watertable, whichever was reached first. About 1 kg of soil sampled with a soil sampler was put into a polyethylene bag, brought to the lab, a subsample measured for moisture content, and then dried under shade.

Soil texture was analyzed by the Queen's method after soil particles were segregated by boiling in 5% ammonium hydroxide solution. Electrical conductivity (EC) of the soil was measured with an electric conductivity meter(Takemura DM 35) following the manufacture's instruction of mixing 10 g of air dried soil with 50 ml dist. water.

RESULTS AND DISCUSSION

Climatic factors

Table 1 shows annual precipitation, annual evaporation and the number of rainy days of the study areas. The annual precipitation average was 1,263 mm for 5 years through it varied considerably every year. The largest was 1,504.2 mm from July 1984 to June 1985 but the smallest was 961.1 mm from July 1988 to June 1989. The annual evaporation rate ranged from 1,039.7 mm to 1,079.0 mm, which was a narrower variation than that of the annual precipitation. The surplus waster of 425.2 mm was recorded

Table 1. The climatic factors of the study area from July 1984 to June 1989

Period	Annual precipitation (mm)	Annual evaporation (mm)	Rainy days			
			Annual rainy days	>5 mm /day	>10 mm /day	>20 mm /day
1984. 7~1985. 6	1504.2	1079.0	132	45	33	20
1985. 7~1986. 6	1334.7	1059.4	125	55	36	20
1986. 7~1987. 6	1158.3	1041.8	135	58	33	19
1987. 7~1988. 6	1356.5	1039.7	101	40	31	22
1988. 7~1989. 6	961.1	1040.1	108	41	28	14
Mean	1263.0	1052.0	120	48	32	19

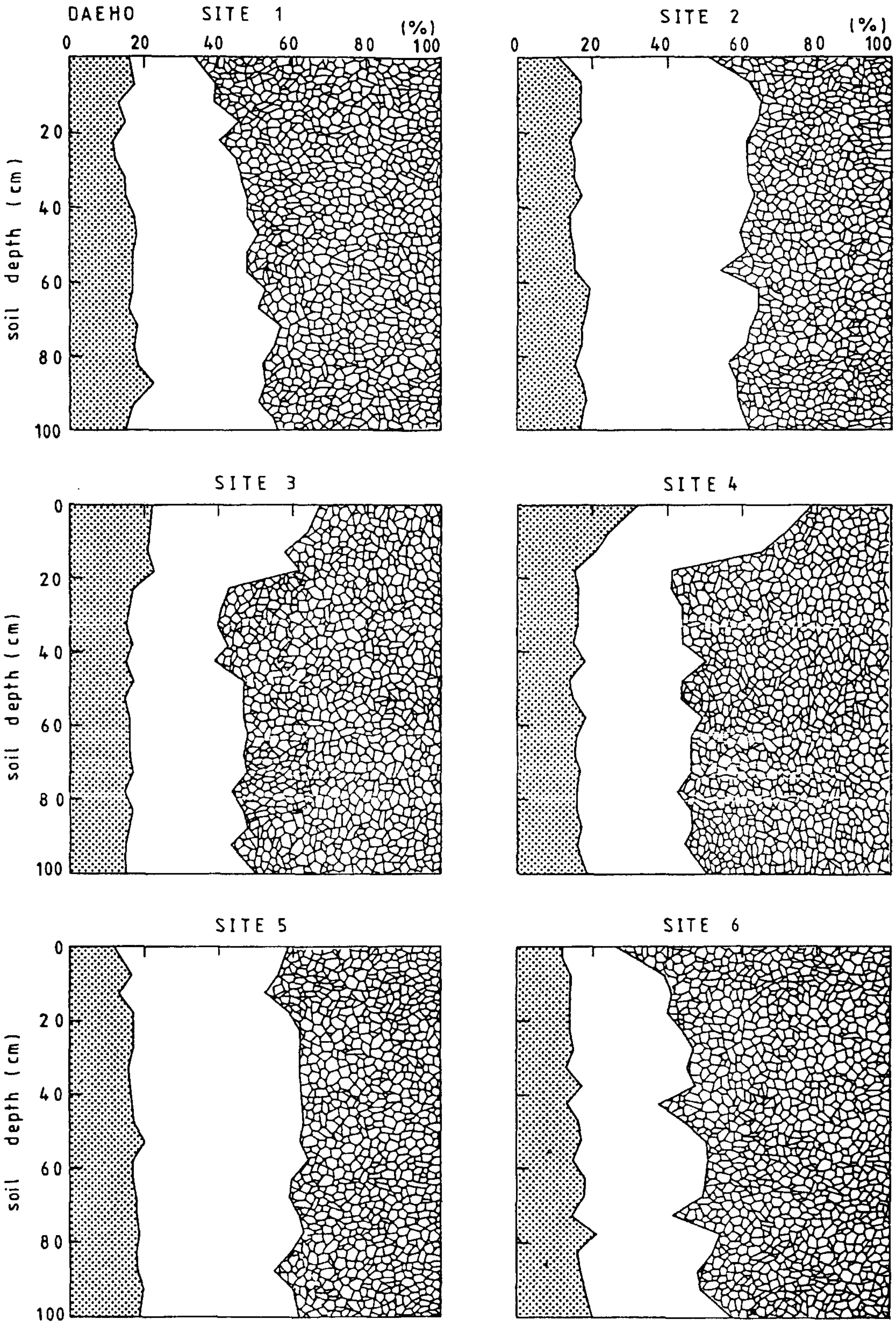
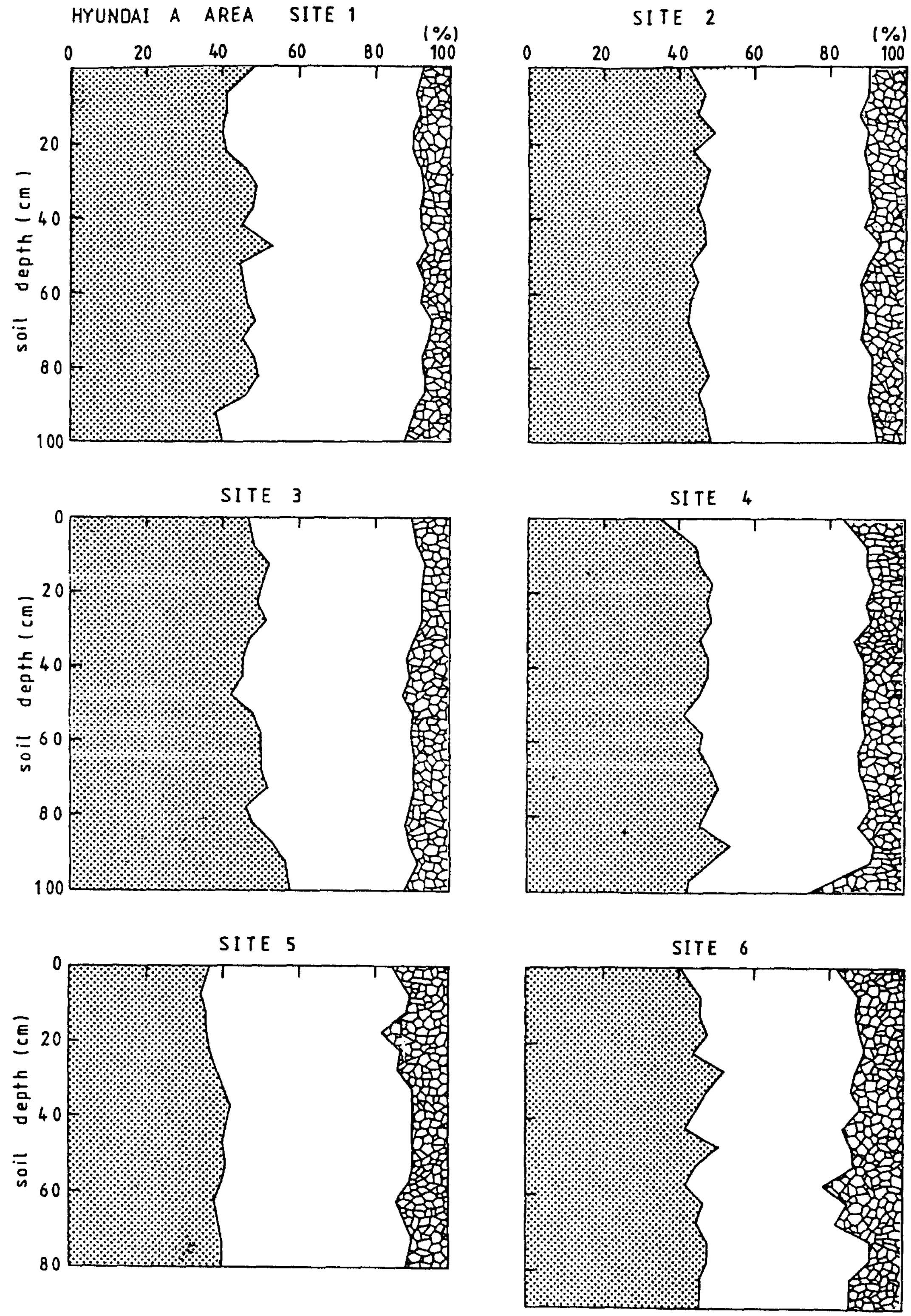


Fig. 2. Continued.



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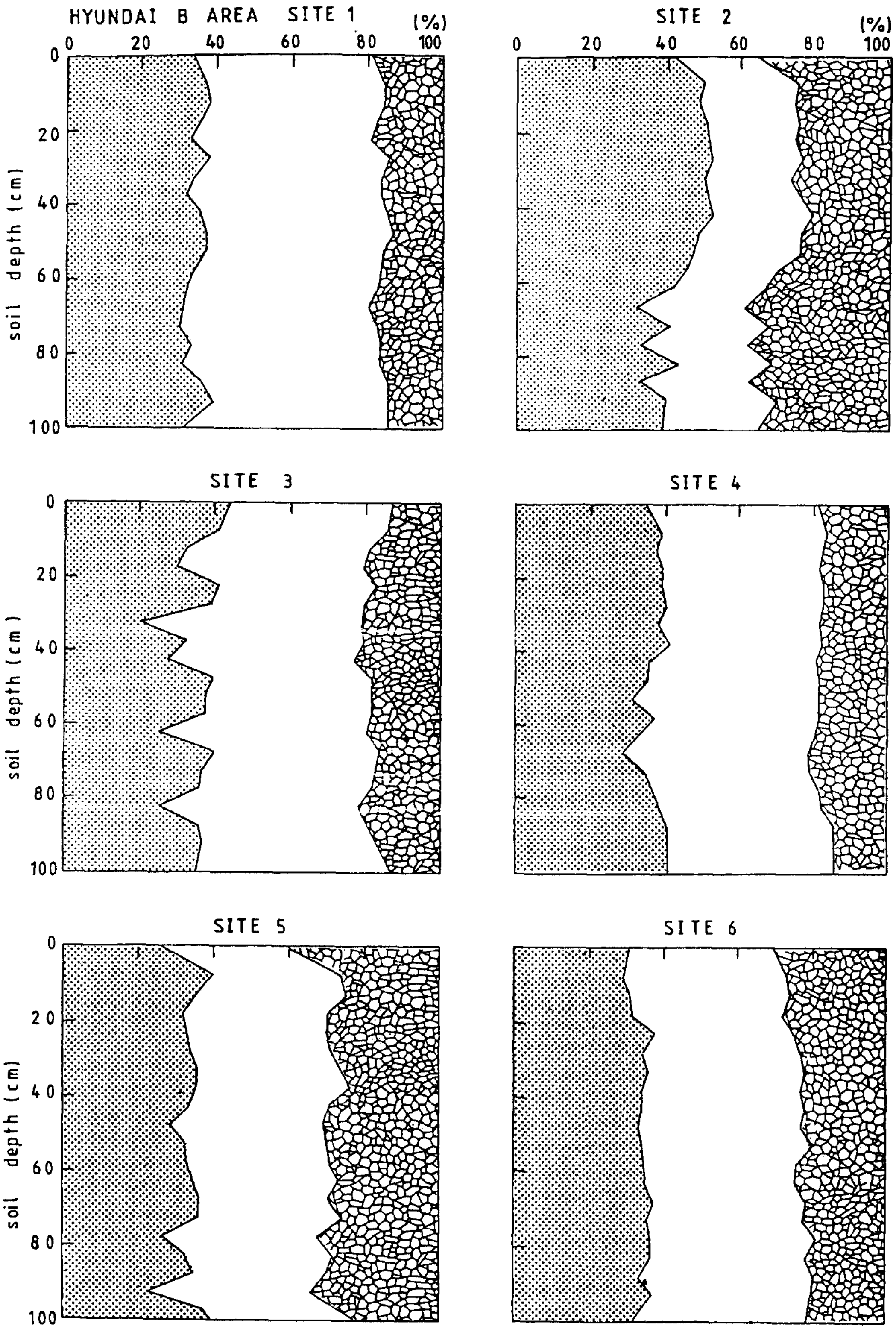

Fig. 2. The vertical changes of soil texture at the different sites of 3 reclaimed lands.

for July 1984~June 1985, and the water deficit of 85.0 mm was observed for July 1988~June 1989.

The number of the rainy days per year were respectively 132, 125, 135, 101 and 108 days from 1984 to 1989. The number of rainy days with over 5 mm of precipitation were as many as 48 days out of the total rainy days but those with over 20 mm were as few as 19 days.

Soil texture

The soil texture in the reclaimed lands of Hyundai A, Hyundai B and Daeho are shown in Fig. 2. The soil of Daeho consisted of 16~17% clay, 30~45% silt and 40~55% sand, so that classified it as loam or sandy loam according to the criteria of the USDA(Soil Survey Staff 1975). The soil texture at sites 1, 3, 4 and 6 of Daeho differed greatly at different depths and different sites, especially the upper zone, from the surface to 50 cm in depth, where the samples were sandy loam with over 50% sand. The soil of sites 2 and 5, however, had a high amount of silt-over 40% vertically.

The soils of Hyundai A were composed of 39~49% clay, 40~49% silt and 8~14% sand, which were classified as silty clay loam or silty clay. The soil textures were horizontally similar in the different sites and vertically similar in the same site(Fig. 2).

The soils of Hyundai B were composed of 22~45% clay, 26~49% silty, and 17~31% sand, which classified them as clay loam, clay or silty clay loam in the different sites. Soil textures were heterogeneous among the sites horizontally and within a site vertically. As will be mentioned later the soil textures of the reclaimed land were profoundly related to the degree of desalination by the percolation of rainwater.

From the above results it is apparent that the sediments have accumulated relative to different factors in the different sites horizontally and at different depths vertically in the same site. This assumption is supported by the results of Wells and Huh (1979) that sediments of tidal flats on the western coast of Korea are predominantly composed of silt and clay in spite of there being sandy tidal flats on the coast(Frey *et al.* 1989). Samples from Nam Yang Bay show mottled, homogeneous and laminate type sedimentation in vertical profile(Alexander *et al.* 1991).

Vertical distribution of electric conductivity

The vertical and temporal changes of electric conductivity(EC) of the soils in Hyundai B are shown in Fig. 3, and soil textures of this site are shown in Fig. 4. Patterns of the EC changed from an S shape to a linear on as the sampling time progressed. The EC values of the upper zone, from the top to 50 cm deep, varied markedly as the depth increased, especially those of top soil fluctuated from the uppermost to the lowermost according to the period of time. The EC values of the lower zone below 50 cm, however, were generally constant regardless of vertical depth. These results suggest that sa!'- contained the reclaimed soil was percolated upwards by capillary water and moved up to the soil surface. Consequently the EC of soil to the criteria of mean values below 50 cm were reduced year by year from 1984 to 1989(Table 2).

Relationship between climatic factors and desalination

Desalination from the soil may be correlated with precipitation, evaporation, rain intensity, and other factors. Although correlations between EC values and climatic factors, such as annual precipitation, evapor-

Table 2. The EC values of soil below 50 cm deep

Year	EC(mmho)
1984	2.13±0.11
1985	1.74±0.10
1986	1.27±0.15
1987	1.19±0.37
1988	0.95±0.20
1989	0.83±0.24

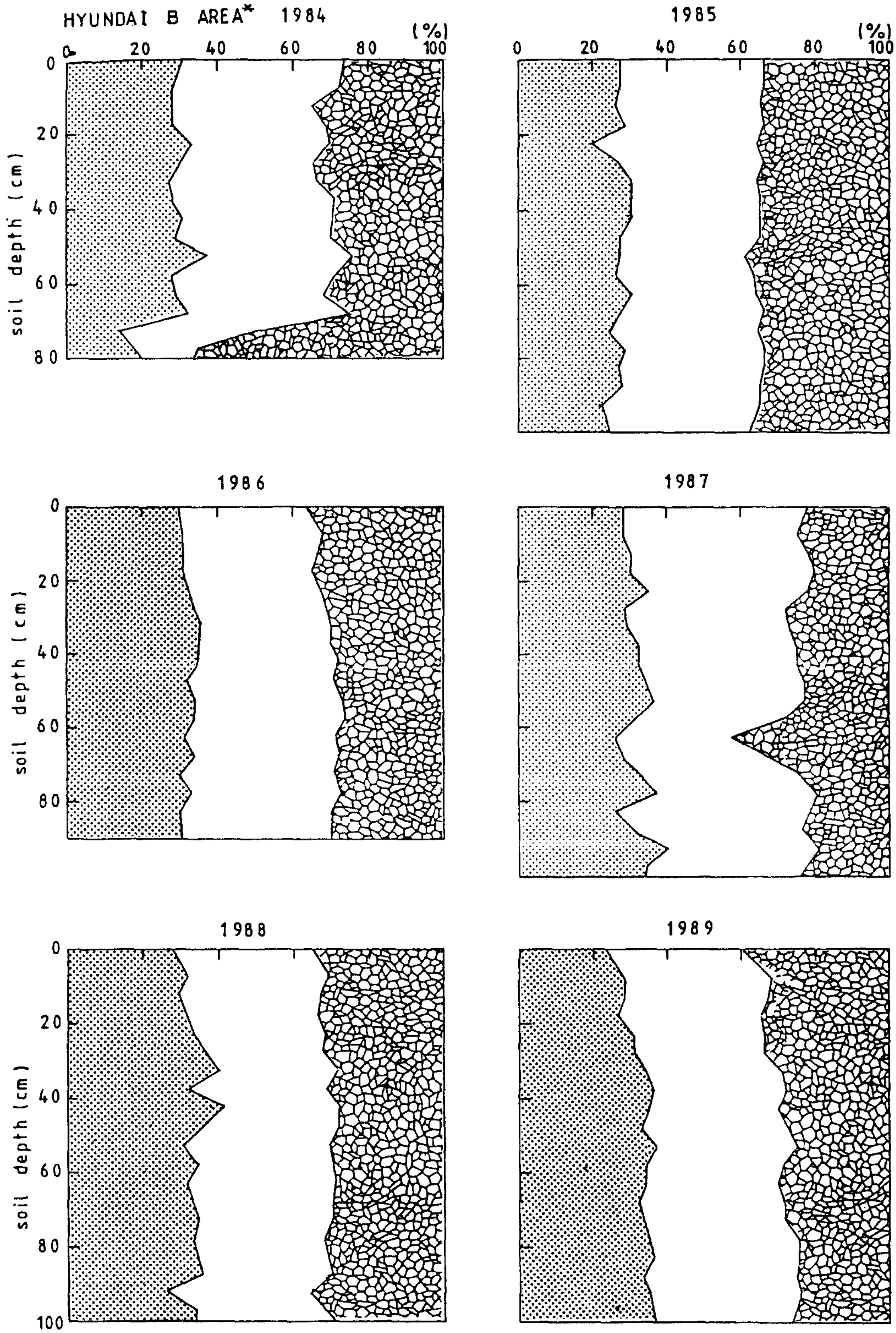

Fig. 3. Vertical changes of EC of reclaimed soil in Hyundai B.

Table 3. Correlation coefficients(r) between the EC values and climatic factors

	Annual precipitation	Annual evaporation	No. of rainy day			
			No.of annual rainy day	>5 mm/day	>10 mm/day	>20 mm/day
*	−0.9815	−0.9722	−0.9776	−0.9753	−0.9777	−0.9748
**	0.7497	0.7567	0.2139	0.1069	0.7505	0.4884

* : Correlation between EC value of soil and cumulative climatic factors.
** : Correlation between decrement of EC value and annual climatic factors.
Significant level at 1%(v=4) is 0.917.

ation or the numbers of rainy days was very high with r=0.9722(Table 3), those among the yearly decrement in the EC and yearly magnitudes of the climatic factors were considerably lower with a range of r=0.1069~0.7569. This result suggests that desalination from the soil was affected by many climatic factors, particulary by the numbers of rainy days of over 10 mm/day other than the numbers of day with other rain intensity.

Salt in the reclaimed land moves vertically downward and upward through a soil profile by the flow of soil water(Chang *et al.* 1978). Gradual desal-

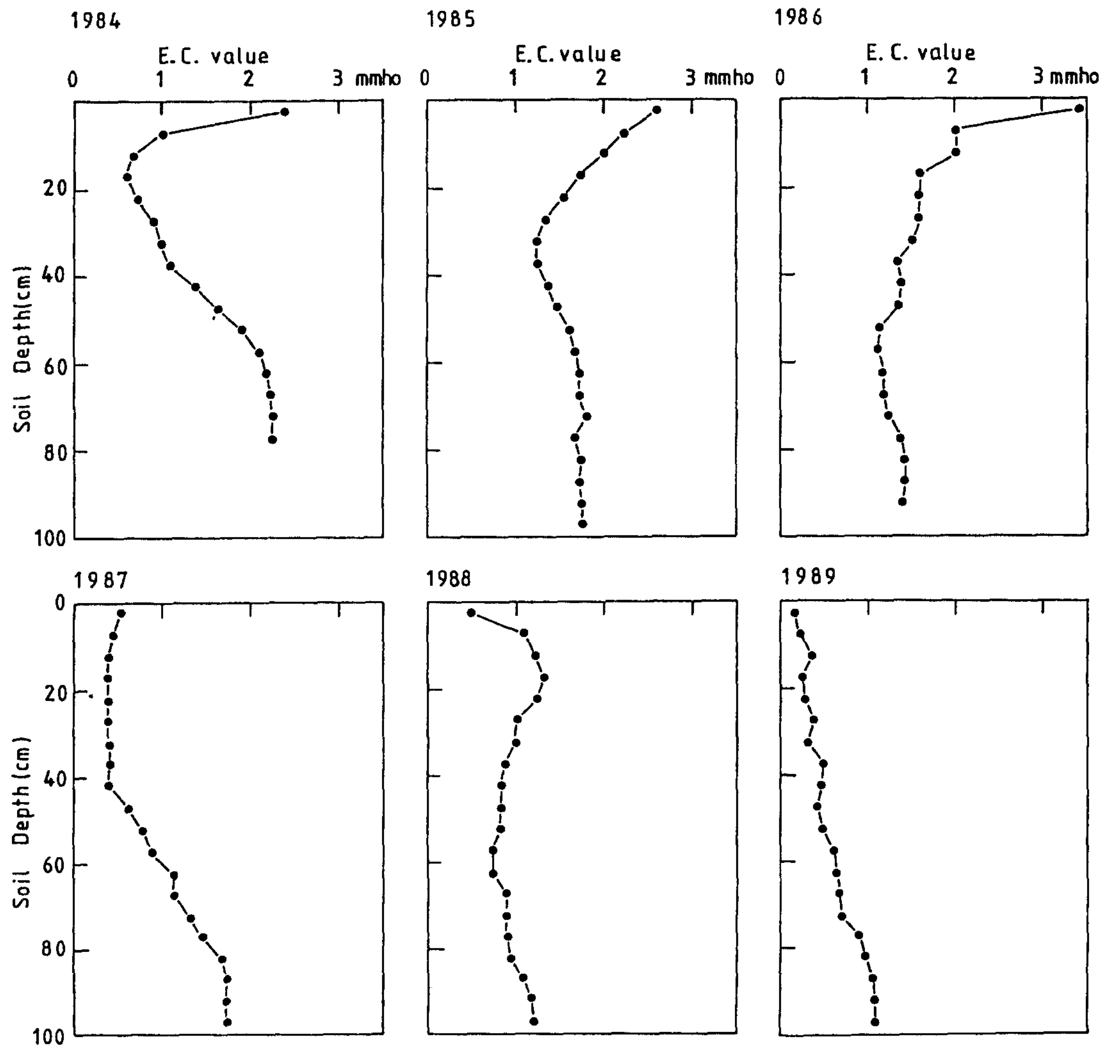

Fig. 4. The vertical changes of reclaimed soil along the year in Hyundai B.

ination form the soil occurs in three ways: by leaching into the watertable; by running out on the soil surface into a tributary when precipitation is higher than evaporation; by accumlating on the soil surface as white crystaline salt when precipitation is less than evaporation. Actually one can often observe white salt crystals on the soil surface of the study area was observed whenever there was prolonged dry weather.

As mentioned above the annual precipitation is over than the annual evaporation in the study area (Tabel 1). The desalination from the reclaimed land is, therefore, expected to be largely due to leaching by the percolation of rain water. The percolation would be greatly accelerated through large particles such as sand but slowed by smaller ones such as clay. Under the same quantity of precipitation desalination by leaching would be high in the reclaimed land of Daeho composed of loam or sandy loam but low in Hyundai A composed of silty clay loam or silty clay(Fig. 2). At any rate, desalination certainly alternates between water running on the soil surface and leaching down through the soil profile. Salt on the soil surface is most efficiently discharged by a sufficient rain intensity of over 10 mm/day(Table 3). By considering the characteristics of the vertical EC distribution, desalination by running water would be rather more dffective than by leaching(Fig. 3).

적 요

한국 서해안(서산)의 간척지인 대호, 현대 A 및 현대 B지구에서 간척 후의 토성을, 현대 B지구에서 1994년부터 1989년까지 탈염을 조사하였다. 현대 A지구의 토성은 채토 장소에 따라 혹은 수직적으로 균질하였으며 39~49%의 점토, 40~49%의 미사 및 8~14%의 모래로 구성되어 있었다. 그러나 대호 지구와 현대 B지구의 토성은 채토 지소나 수직적으로 변이가 심하였다. 대호 지구의 토성은 15~17%의 점토 30~45%의 미사 및 40~55%의 모래로, 현대 B지구의 것은 22~45%의 점토, 26~49%의 미사 및 17~31%의 모래로 구성되어 있었다. 염의 총화를 나타내는 지표인 전기전도도는 매년 감소하였다. 지표로부터 50 cm 이내의 전기전도도는 시간적으로나 수평적으로 변이가 매우 심하였으나 이하의 것은 비교적 일정한 형태를 보였다. 그리고 토양의 전기전도도와 연강수량, 연증발량, 연강수일수 또는 강수강도별 일수 사이에는 −0.97 이상의 음의 상관을 보였고, 전기전도도의 감소량과 연강수량, 연증발량 및 10 mm/day 이상의 강수일수 사이에도 0.7 이상의 양의 상관을 보였다. 강수일수 중에서는 특히 10 mm/day 이상의 상관계수가 가장 높은 것으로 보아 하루에 10 mm 이상의 강수에서 탈염효과가 가장 높다고 판단되었다.

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