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[Short Communication]

Physical and Chemical Characteristics of Dokdo Soil

Gil Seong Lee and Yeon Sik Choo*

Department of Biology, Kyungpook National University, Daegu, 702-701, Korea

ABSTRACT: To understand the properties of soil in Dokdo, we collected soil samples from 12 locations on Seodo and 23 locations on Dongdo, in Dokdo of Gyeongsangbuk-do Province in 2007-2008 and analyzed the soil's physical and chemical characteristics. Sand comprises the largest component (49.37%) of Dokdo soil, followed by silt (40.70%) and clay (9.93%). The soil structure consists mostly of sand loam, followed by loam and silt loam. The pH level of soils from Dokdo varied dramatically among sampling sites and seasons, ranging from 3.36 to 8.02. The total ion content of Dokdo soil also varies greatly among survey places and periods, but in general the total ion content was high in summer when vegetation develops, and low in spring. The exchangeable cation contents of the soil showed low levels in samples where the soil pH was low, including habitats dominated by *Agropyron tsukushiense* var. *transiens* and *Echinochloa crus-galli*, whereas the exchangeable cation contents were high where the organic contents were high, as in habitats dominated by *Liriope platyphylla* and *Artemisia japonica* subsp. *littoricola*. Soil N contents varied greatly among survey sites and higher N contents were found in soil inhabited by Chenopodiaceous plants than in habitats inhabited by other plants. The substantial differences in phosphorus contents among sites were related to excrement of black-tailed gulls. To understand the basic physical and chemical features of the soil on Dokdo, it will be necessary to conduct seasonal and long-term research on soil pH, ion contents, organic contents, N and P, as well as obtaining precise data from samples collected at different depths.

Key words: Dokdo, exchangeable cations, organic matters, soil characteristics, soil pH

INTRODUCTION

Located in the East Sea (also known as the Sea of Japan) in the Northwestern Pacific Ocean, Dokdo is a volcanic island group consisting of around 89 small islands and rocks centered around Dongdo (East Island) and Seodo (West Island). Dokdo is vulnerable to seismic vibrations, strong winds and heavy rainfall throughout the year, resulting in severe soil erosion. Intense direct sunlight, physical stress from strong winds, and physiological stress from salty sea winds have made it difficult for plants to settle on Dokdo, resulting in poor vegetation growth.

Tourism and fishery activities around Dokdo, which were recently initiated with the goal of strengthening Korean sovereignty over Dokdo, may now be threatening its ecosystem. The remote land environment of Dokdo supports a unique ecosystem with beautiful marine surroundings and bountiful, almost-intact fishery resources. Thus, Dokdo was designated as a natural sanctuary, No. 336 Precious Natural Treasure, in November 1982 and has been preserved as a special island since December 1997 in accordance with the Special Act on the Ecosystem Conservation of Small Islands.

So far, academic research on the natural environment of Dokdo has focused on the fauna, flora, and marine biota of Dokdo and its geographical and topographical features. The Korean National Council for Conservation of Nature (KNCCN) conducted some research on the soil of Dokdo as a biological habitat in 1995, 2006 and 2007, but no other significant research has yet examined Dokdo's soil properties in detail. The purpose of our research was to better understand the characteristics of Dokdo soil and to provide information that can be used to protect the ecosystem of Dokdo in the future.

MATERIALS AND METHODS

Soil sampling

For the analysis of soil environments, we collected 0.5 kg

*Corresponding Author; Phone: +82-53-950-5346, e-mail: yschoo@knu.ac.kr

Table 1. Soil collection sites and dominant plant species in Dokdo

Sites	Latitude & Longitude	Altitude (m)	Dominant plant species
Dongdo Islet			
E1	N37°14'10.6", E131°52'15.7"	18	*Aster spathulifolius*
E2	N37°14'10.5", E131°52'16.0"	22	*Agropyron tsukushiense* var. *transiens*
E3	N37°14'10.2", E131°52'16.4"	22	*Festuca rubra*
E4	N37°14'09.5", E131°52'17.4"	30	*Tetragonia tetragonoides*
E5	N37°14'09.3", E131°52'17.6"	29	*Rumex japonicus*
E6	N37°14'09.1", E131°52'17.9"	28	*Agropyron tsukushiense* var. *transiens*
E7	N37°14'09.8", E131°52'17.4"	40	*Lilium tigrinum*
E8	N37°14'09.4", E131°52'18.6"	40	*Festuca rubra*
E9	N37°14'08.3", E131°52'19.9"	46	*Agropyron tsukushiense* var. *transiens, Echinochloa crusgalli*
E10	N37°14'09.5", E131°52'18.9"	56	*Aster spathulifolius*
E11	N37°14'09.9", E131°52'19.2"	67	*Dianthus superbus* var. *longicalycinus*
E12	N37°14'06.6", E131°52'19.3"	69	*Asparagus schoberioides*
E13	N37°14'11.4", E131°52'18.0"	76	*Portulaca oleracea*
E14	N37°14'12.3", E131°52'19.1"	83	*Artemisia japonica* subsp. *littoricola, Aster spathulifolius, Agropyron tsukushiense* var. *transiens*
E15	N37°14'12.5", E131°52'15.9"	85	*Artemisia japonica* subsp. *littoricola*
E16	N37°14'12.5", E131°52'20.4"	91	*Chenopodium album* var. *centrorubrum*
E17	N37°14'13.3", E131°52'21.4"	93	*Agropyron tsukushiense* var. *transiens*
E18	N37°14'14.3", E131°52'23.6"	82	*Echinochloa crusgalli*
E19	N37°14'14.7", E131°52'24.3"	77	*Chenopodium stenophyllum*
E20	N37°14'15.3", E131°52'23.7"	61	*Cyrtomium falcatum*
E21	N37°14'15.9", E131°52'23.6"	49	*Agropyron tsukushiense* var. *transiens*
E22	N37°14'16.4", E131°52'23.8"	33	*Agropyron tsukushiense* var. *transiens, Echinochloa crusgalli, Achyranthes japonica*
E23	N37°14'16.7", E131°52'24.3"	29	*Sedum oryzifolium*
Seodo Islet			
Sites	Latitude & Longitude	Altitude (m)	Dominant plant species
W1	N37°14'18.8", E131°52'01.8"	152	*Artemisia japonica* subsp. *littoricola*
W2	N37°14'18.7", E131°52'01.7"	145	*Agropyron tsukushiense* var. *transiens, Echinochloa crusgalli*
W3	N37°14'18.6", E131°52'01.5"	139	*Chenopodium album*
W4	N37°14'18.6", E131°52'01.1"	136	Bare ground
W5	N37°14'18.9", E131°52'00.3"	133	*Liriope platyphylla*
W6	N37°14'18.4", E131°52'01.4"	126	*Artemisia japonica* subsp. *littoricola*
W7	N37°14'16.6", E131°52'00.4"	106	Bare ground
W8	N37°14'16.2", E131°52'00.9"	93.3	*Agropyron tsukushiense* var. *transiens*
W9	N37°14'15.8", E131°52'02.1"	90	*Echinochloa crusgalli, Agropyron tsukushiense* var. *transiens*
W10	N37°14'16.4", E131°52'02.4"	90	*Sedum oryzifolium*
W11	N37°14'16.6", E131°52'02.9"	72	*Reynoutria sachalinensis*
W12	N37°14'16.3", E131°52'04.9"	33	*Tetragonia tetragonoides, Lysimachia mauritiana*

soil samples at 0-10 cm depths at three randomly selected places in August 2007 and in April and June 2008 from 12 locations on Seodo and 23 locations on Dongdo in Dokdo, Korea (Table 1 and Fig. 1). The collected soils were air-dried and analyzed using standard methods.

Soil particle sizes, pH, total ionic contents, and exchangeable cations

Soil particle sizes were analyzed at the Rural Development Administration. Soil samples (5 g) were added to 25 ml distilled water and shaken for 1 hr. After the soil solution was filtered through filter paper (Whatmann No. 40, 110 mm), soil pH and total ion contents were measured using a pH meter (Orion US/710) and an electronic conductivity meter (MX300 X-matepro: Mettler-Toledo). Soil exchangeable cations extracted by 1 N HN_4OAc and CH_3COOH were determined by ICP mass spectrometer (Korean Basic Science Institute).

Organic contents, total nitrogen and soluble phosphates

The organic matter contents were estimated by loss of dry mass on ignition at 550°C. Total nitrogen was measured using the micro-Kjeldahl method. Soluble phosphorus contents were measured by the P_2O_5 Lancaster

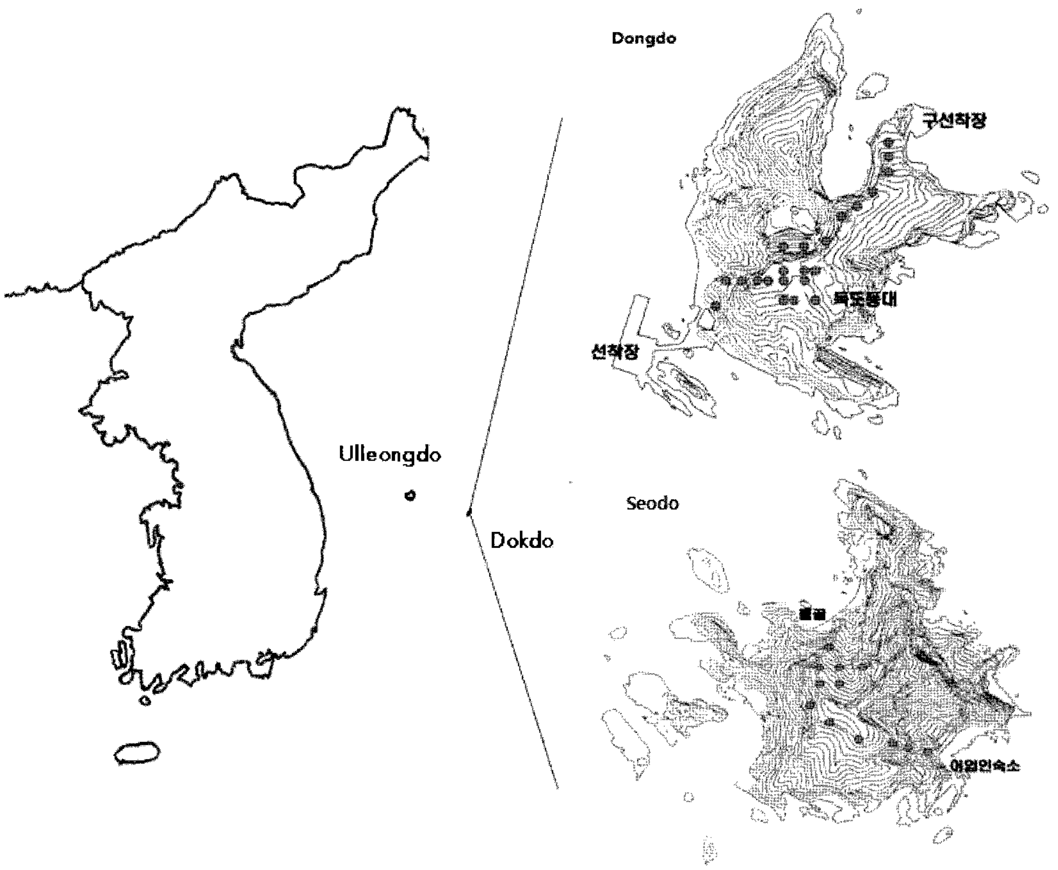


Fig. 1. Study area and sampling sites (black circle) in Dokdo, Korea

method.

RESULTS AND DISCUSSION

Physical characteristics of Dokdo soil

The parent rocks of Dokdo are of volcanic origins and are alkaline. The main rock above the sea level is andesite, whereas basalt is believed to cover most of the undersea area of Dokdo. Like trachyte, andesite is a neutral volcanic rock. Its main component is plagioclase, but it also contains pyroxene, hornblende, biotite, etc. (Jang and Park 2008)

Dokdo soils are residual dark brown soils with a steep parallel plane >30° that have been weathered from the top of the mountain over a long period of time. As Dokdo is a small area with deep undulations and steep inclines heavily influenced by weathering and erosion, its soil development has been weak and its soil layers are regarded as residual soils formed by a long period of weathering from parent rocks and showing a very limited distribution. The soil depth of Dongdo (East Island) is 60 cm at its deepest point, but it is generally ~10 cm (KIGAM 2006 & 2008). The soil depth of Seodo ranges from 3 to 25 cm and regions on the islet with <5 cm soil depth are widely distributed (KIGAM 2008). Soil layers with >1 m depth stretch from the top to Mulgol. Soil particles covered with vegetation in Dokdo are so closely attached to the roots of plants that soil loss is unlikely, but a few exposed areas of Dongdo and Seodo are losing some soil (http://www.dokdocenter.org). The soil around Seongin Peak in Ulleungdo, the island nearest to Dokdo, is humid forest soil with a 1-2 cm thick organic layer (or litter layer) (Jin et al. 1994).

The specific gravity of the soil layer in Dokdo ranges from 2.47 to 2.64 sp. gr. Dokdo soils have a relatively high natural moisture content, ranging from 16.03 to 40.89% and averaging 23.84%. The liquid limit stays between 30.31% and 46.61%. As the soil layers of Dongdo contain many coarse-grained substances, they are categorized as non-plastic, while those of Seodo are regarded as mid-plastic with a plastic limit of between 14.78% and 27.27% (Kim et al. 2009).

According to the data from twenty-five points on Dokdo (Table 2), sand comprises the largest component of Dokdo soil (49.37%), followed by silt (40.70%) and clay (9.93%). Most of the soil structure of Dokdo consists of sand loam, followed by loam and silt loam. The sequence of particle

Table 2. Soil separates from Dokdo (VCS: Very coarse sand, CS: Coarse sand, MS: Medium sand, FS: Fine sand, VFS: Very fine sand).

NO	Sample sites	Particle Size Distribution			Texture	Sand fraction (%)				
		Sand	Silt	Clay		VCS (2-1 mm)	CS (1-0.5)	MS (0.5-0.25)	FS (0.25-0.1)	VFS (0.1-0.05)
1	E1	55.7	33.4	10.9	sandy loam	7.0	14.2	15.4	12.1	7.0
2	E2	50.1	31.5	18.4	loam	5.9	10.3	12.2	14.8	6.8
3	E3	55.4	39.4	5.2	sandy loam	18.1	8.6	6.8	14.6	7.3
4	E4	70.1	24.3	5.6	sandy loam	6.9	17.9	21.4	17.9	6.0
5	E6	54.2	34.3	11.5	sandy loam	10.0	14.1	13.1	11.5	5.4
6	E9	39.3	49.6	11.1	loam	2.6	7.9	10.2	10.2	8.4
7	E10	59.6	35.6	4.8	sandy loam	6.1	10.6	15.3	18.1	9.4
8	E11	55.7	37.5	6.8	sandy loam	6.2	11.7	16.8	14.6	6.4
9	E12	40.2	48.2	11.6	loam	3.7	7.7	10.6	12.1	6.1
10	E13	38.3	46.9	14.8	loam	4.5	10.4	9.2	8.8	5.5
11	E14	48.4	42.8	8.8	loam	4.9	8.4	14.4	14.0	6.8
12	E15	38.7	55.3	6.0	silt loam	2.8	6.3	8.0	9.2	12.4
13	E16	54.6	38.6	6.8	sandy loam	4.7	9.8	13.8	17.5	8.8
14	E17	62.5	28.3	9.2	sandy loam	15.5	18.8	12.4	9.0	6.9
15	E18	40.6	51.8	7.6	silt loam	4.2	7.6	10.9	11.3	6.5
16	E19	35.5	57.7	6.8	silt loam	2.4	3.2	6.4	11.8	11.7
17	E21	37.0	52.6	10.4	silt loam	3.1	8.0	9.4	10.3	6.3
18	E23	62.3	26.1	11.6	sandy loam	16.4	22.3	12.8	7.5	3.4
19	W1	60.2	31.0	8.8	sandy loam	21.4	18.6	11.7	6.2	2.4
20	W3	51.1	38.3	10.6	loam	7.7	16.3	9.6	4.9	12.7
21	W4	53.9	29.8	16.3	sandy loam	12.7	14.1	7.0	6.1	14.0
22	W8	43.2	39.4	17.4	loam	3.2	9.3	6.6	5.6	18.5
23	W9	32.3	57.4	10.3	silt loam	3.0	7.9	6.4	6.4	8.7
24	W10	34.6	48.5	17.0	loam	2.3	5.1	7.0	11.6	8.6
25	W11	60.8	39.2	0.0	sandy loam	3.4	9.3	9.6	11.3	27.1
	Mean	49.37	40.7	9.93		6.95	10.75	10.67	10.68	8.58

sizes is as follows from the largest to the smallest: CS > FS > MS > VFS, and VCS, with most of the soil consisting of CS from 1 to 0.5 mm (Table 2). However, on Dongdo of Dokdo, silt comprises most of the soil (73.4%), followed by sand (21.2%) and clay (5.36%). Fine-grained silt and silt loam form most of the soil structure of Dongdo, which stands in contrast to the results of Jeon (2008).

Chemical characteristics of Dokdo soil

Soil pH: Low soil pH can occur as a result of disassociated hydrogen ions that are produced when organic substances in the soil dissolve and are weakly absorbed in the soil colloid. The average pH measured in samples collected at eleven points on Dongdo ranged from 4.86 to 8.02 and the average soil pH on Seodo in 2006 ranged from 3.36 to 6.95 (Gyeongsangbuk-do 2006). However, in our survey in 2007 and 2008, there were some changes in the pH levels of Dokdo soil. The average pH of samples collected from twenty-three points on Dongdo ranged from 3.81 to 7.78 and the average pH from samples collected at eleven points on Seodo ranged from 4.11 to 7.49 (Fig. 2). On Seodo, soil from *Agropyron tsukushiense* var. *transiens* communities (W1) had the lowest pH value (4.11) and the pH of soil from the point W4, which had no vegetation, was the highest (7.49) in the sample. On Dongdo, the lowest pH was found in soil from an area inhabited by *Echinochest crus-galli, Echinochest crus-galli – Agropyron tsukushiense* var. *transiens – Achyranthes japonica* and the highest soil pH was measured in soil collected from a *Portulaca oleracea* habitat in August. The low soil pH levels in some areas of Dokdo may play a pivotal role in permitting the survival of Dokdo plants by preventing inorganic salts from being absorbed into the soil. In general, the pH level of forest soil ranges from 4.0 to 6.0 and that of brown forest soil ranges from 5.3 to 5.5. However, the soil pH on Dokdo differed dramatically among sampling locations and seasons, ranging from 3.36 to 8.02. This is because the vegetation of Dokdo, where a stable forest has not developed, changes every season. Moreover, the excrement produced by large groups of black-tailed gulls that inhabit Dokdo is believed to have had a pronounced effect on soil pH levels in Dokdo. Generally birds and reptiles residing in desert areas store urea inside their bodies and discharge it not as urine but as uric acid ($C_5H_4O_3N_4$). Thus, bird excrement is strongly acid, with pH ranging from 3.5 to 4.5, and can affect soil

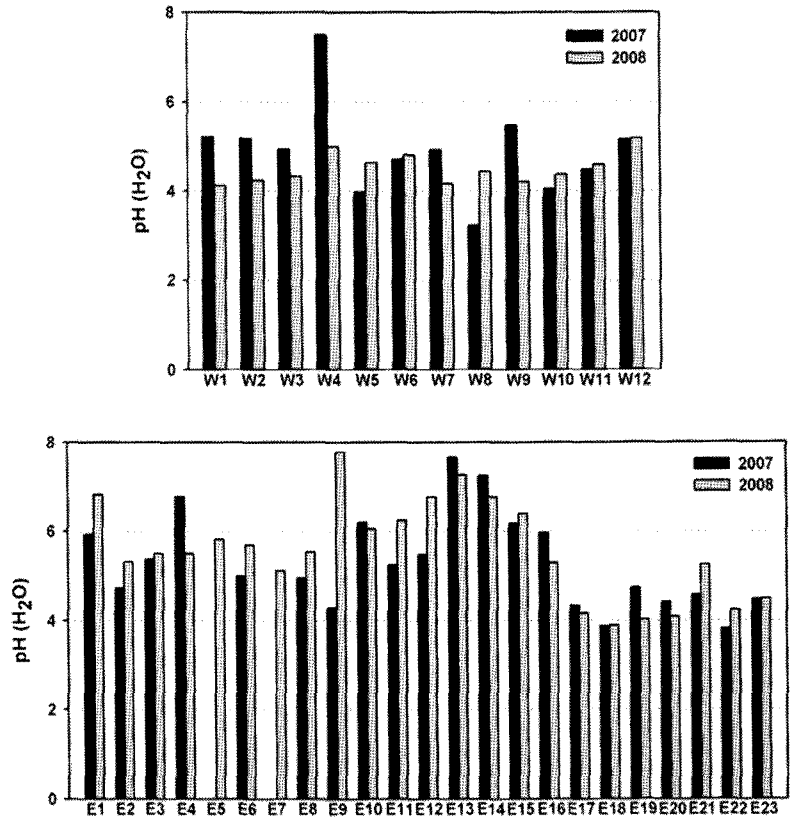


Fig. 2. Dokdo soil pH in 2007-8 (above, Seodo; below, Dongdo)

pH in the areas in which it is deposited. According to a 2001 survey by the Cultural Heritage Administration of Korea (2003), the pH levels of soils from Hongdo, Shindo, and Chilsando where groups of black-tailed gulls live were 3.9-4.5, 4.5, and 5.1, respectively. Bird excrement may cause eutrophication, and the reduced pH level of the soil can lead to withering and death of vegetation. Conversely, the soil in which the acidity has been neutralized by the salt supplied to the soil by sea fog and alkali sea water may show a rather higher pH level.

Total ion and exchangeable cation contents

The total ion contents of Seodo soil ranged from 31.7 to 82.8 ueq/g soil. Site W9 of Seodo, which was inhabited by a *Agropyron tsukushiense* var. *transiens* – *Echinochloa crus-galli*, showed the highest pH level. The total ion contents of Dongdo soil ranged from 26.4 to 119.8 ueq/g soil (Fig. 3).

The highest pH level on Dongdo was from a *Agropyron tsukushiense* var. *transiens* – *Echinochloa crus-galli* community (E9). It is regarded that, like the survey conducted in 2006, the high ion content in *Agropyron tsukushiense* var. *transiens-Echinochloa crus-galli* communityies is probably related to the low pH level of *Agropyron tsukushiense* var. *transiens* – *Echinochloa crus-galli* community, a representative herbaceous plant community of Dokdo.

The total ion contents of Dokdo soil varied greatly among survey locations and periods, but in general the total ion contents were high in summer when vegetation developed and low in spring when it did not develop very much. A variety of factors including sea water scattering and group breeding of black-tailed gulls between April and July are thought to influence the temporal and spatial variation in the total ion contents in the soil of Dokdo.

The exchangeable cation contents of soil samples from Dongdo ranged from 58 to 269 umol/g and those of soil from Seodo soil ranged from 24 to 205 umol/g soil in 2006 (refer to Gyeongsangbuk-do 2006). However, in our study in 2007 and 2008, the exchangeable cation contents of soil samples from Dongdo ranged from 17.6 to 99.9 umol/g soil (Fig. 4) and those of soil samples from Seodo ranged from 29.1 to 127.6 umol/g soil (Fig. 5), which are slightly lower than the values in 2006.

In general, the greater the cation exchange capacity of natural soil, and the higher the humus and clay contents are, the more eroded organic substances in the soil become, and the greater the electric conductivity of the soil. In addition, differences in the exchangeable cation contents among locations on Dongdo and Seodo are closely related to the total ion contents and to the types of

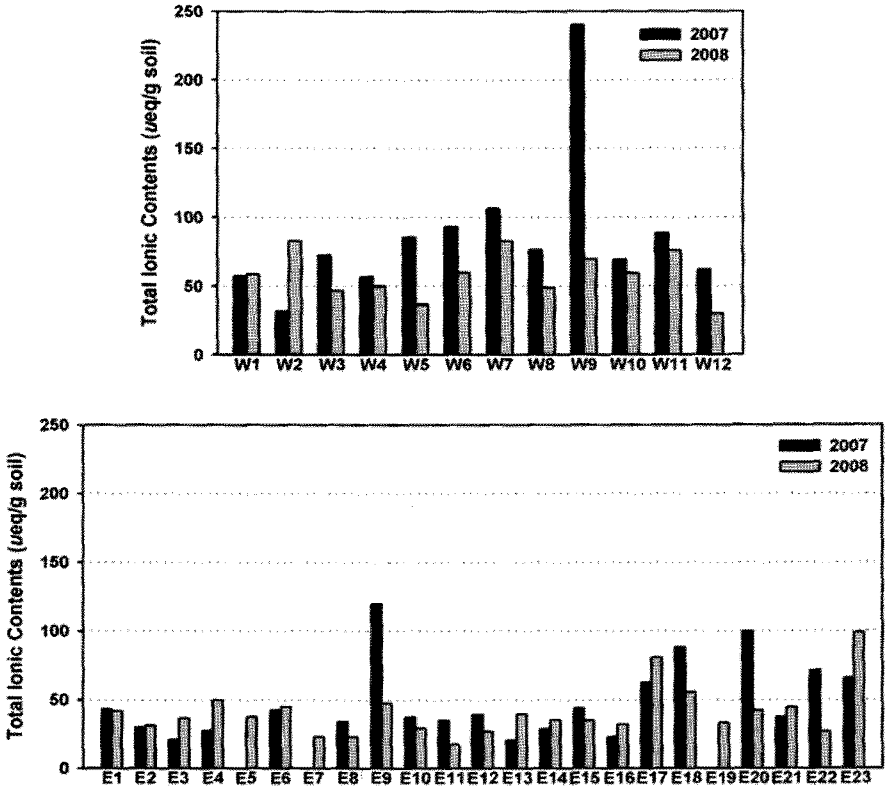


Fig. 3. Total ionic contents of soil from Dokdo in 2007-8 (above, Seodo; below, Dongdo)

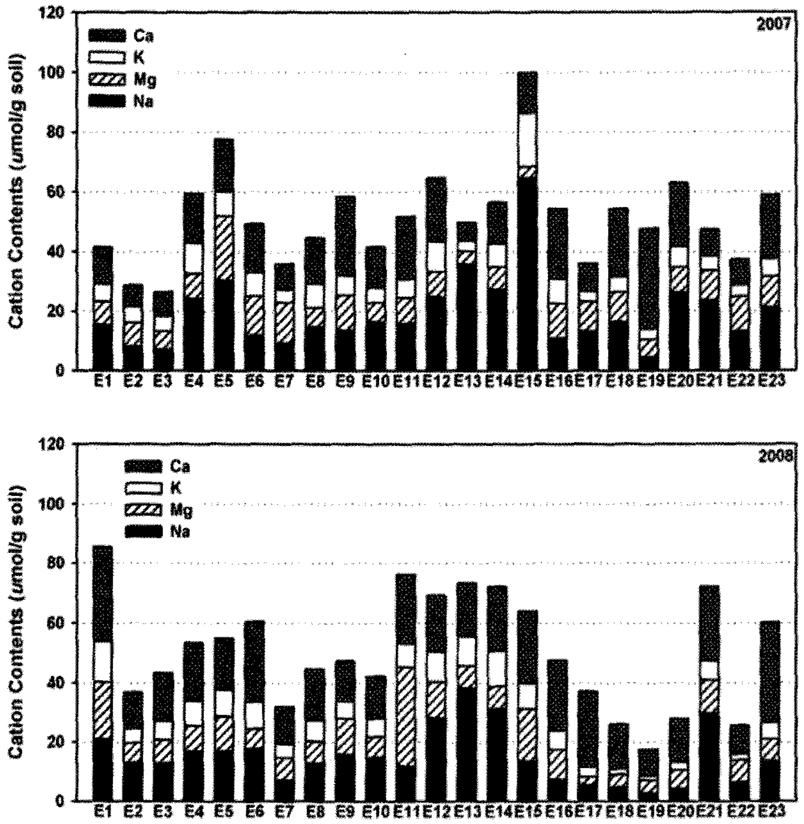


Fig. 4. Exchangeable cation contents of soil from Dongdo (2007-8)

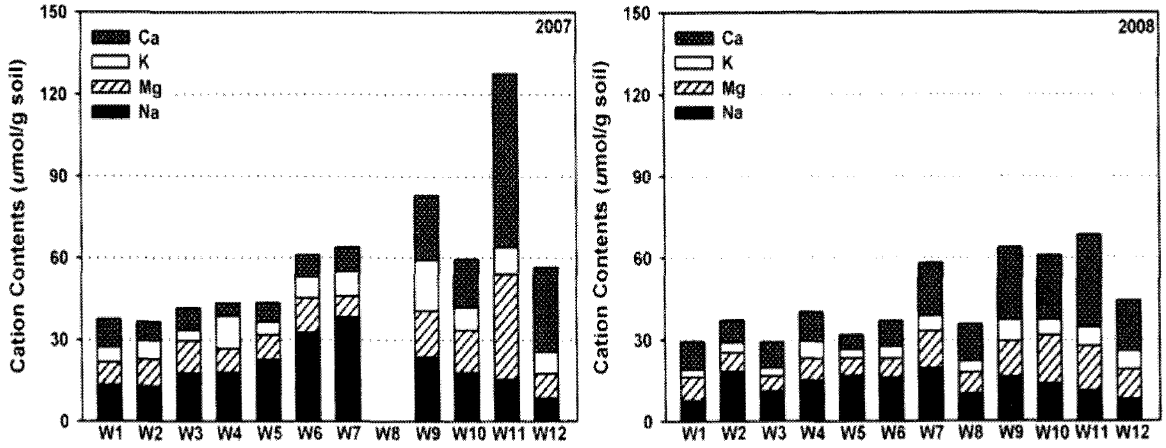


Fig. 5. Exchangeable cation contents of soil from Seodo (2007-8)

organic substances released into the soil by animals and plants.

The exchangeable Mg^{2+} and K^{+} contents of the soil did not differ much among the survey points, but the content of exchangeable Ca^{2+} increased as the altitude increased, with high exchangeable Ca^{2+} content in soil at 110-120 m above sea level in Seodo and at 70-90 m above sea level in Dongdo. The high exchangeable Ca^{2+} content in Dokdo soil is likely to have resulted from the addition of Ca^{2+} to the soil by the eggs of black-tailed gulls after the chicks have hatched. The soil in low-lying areas of Dokdo had a high exchangeable Na^{+} content, which may have been influenced by the scattered sea wind and waves. In general, the soil exchangeable cation contents were low where the soil pH level was low, including the habitats of *Agropyron tsukushiense* var. *transiens* and *Echinochloa crus-galli*, whereas they were high where the organic substance content was high, as in the habitats of *Liriope platyphylla* and *Artemisia japonica* subsp. *littoricola*. In other words, low exchangeable cation contents are closely related to the loss of surface soil resulting from strong sea winds, to low pH soil levels, and to low organic contents. When organic substances from roots or leaves are mixed into the soil, they are dissolved by various microbes.

Total nitrogen and soluble phosphorus contents

Organic nitrogen changes to inorganic forms such as ammonium and nitrate nitrogen, which can influence the nitrogen content in the soil, including the nitrogen in the excrements of birds.

In the 2006 survey, Dongdo showed a higher total nitrogen content (0.09 to%-1.60%) than Seodo (0.06% to 0.74%). The soil nitrogen content on Seodo in 2007 ranged from 0.37% to 1.93%, except for the W6 sampling point, which is inhabited by *Artemisia japonica* subsp. *littoricola*.

The nitrogen content in the soil of Dongdo ranged from 0.23% to 1.46% (Fig. 6), and most soil from Dokdo showed a slightly higher nitrogen content than the world average of 0.15% (Brady 1990). However, the soil from some areas of Dokdo contain <0.2% nitrogen, which is the minimum amount of nitrogen needed for plant growth; this makes it hard for plants to settle and grow in some areas of Dokdo. The nitrogen content of soil from sampling site W6 on Seodo, a habitat of *Artemisia japonica* subsp. *littoricola*, was very high at 3%. This undoubtedly results from the decomposition of large quantities of dead plants and bird excrement in the soil. Nitrogen contents were also higher in soils inhabited by Chenopodiaceous plants than in the habitats of other types of plant.

The survey in 2006 found soluble phosphoric acid contents in soil from Seodo ranging from 245 to 2,154 mg/kg soil, which was higher than the phosphoric acid contents of soil from Dongdo, which ranged from 116.3 to 1,177 mg/kg soil (Gyeongsangbuk-do 2006). In our surveys in 2007 and 2008, however, the soluble phosphoric acid contents of Seodo soil ranged from 31.2 to 429.3 mg/kg soil while the phosphoric acid contents of Dongdo soil ranged from 19.2 to 191.8 mg/kg soil (Fig. 7).

The relatively low phosphoric acid content in Dokdo in 2007 compared to that of 2006 is likely due to high rainfall in 2007. The soil of Dongdo and Seodo alike showed higher phosphoric acid contents than brown forest soils in peninsular South Korea, which range from 8.3 to 42.7 ppm in the 'A' soil layer and from 3.1 to 15.3 ppm in the 'B' layer. The higher phosphoric acid levels on Dokdo can be attributed to excrement from breeding groups of black-tailed gulls (Table 1), and the higher phosphoric acid content of soil on Seodo, compared to that on Dongdo, may result from the presence of larger numbers of black-tailed gulls. Similarly, higher phosphoric acid contents

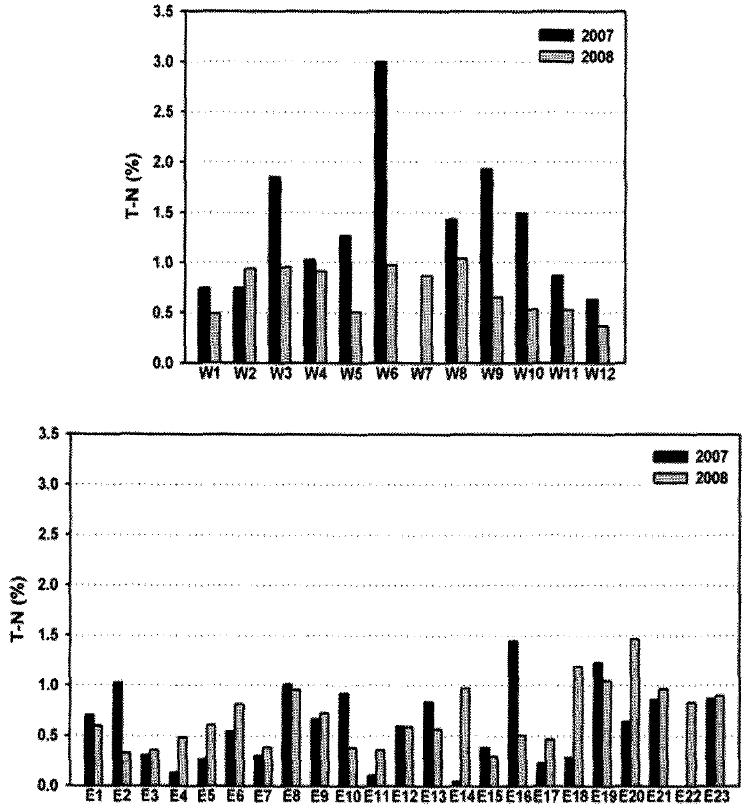


Fig. 6. Total nitrogen contents of soil from Dokdo (above, Seodo; below, Dongdo).

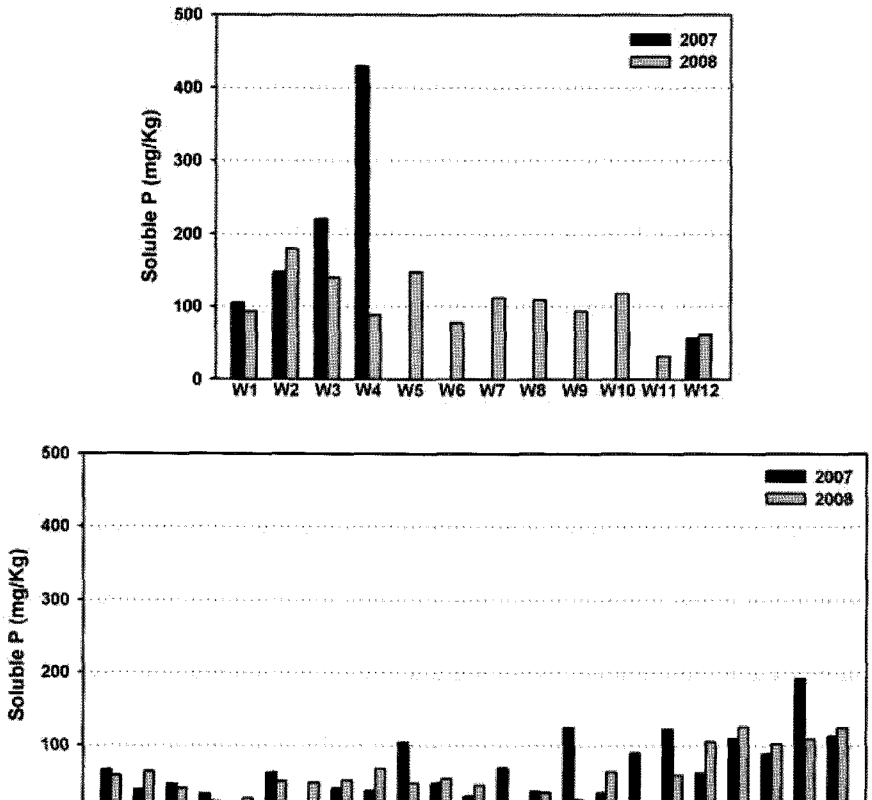
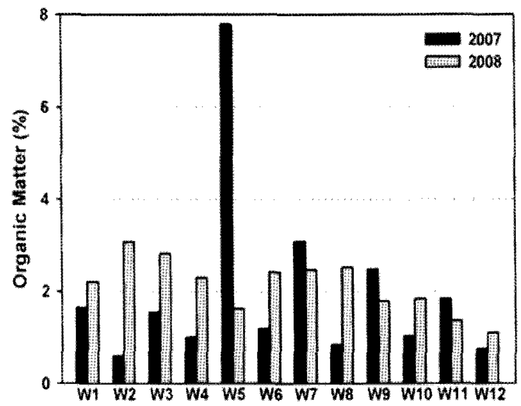


Fig. 7. Soluble phosphorus contents of soil from Dokdo in 2007-8 (above, Seodo; below, Dongdo).



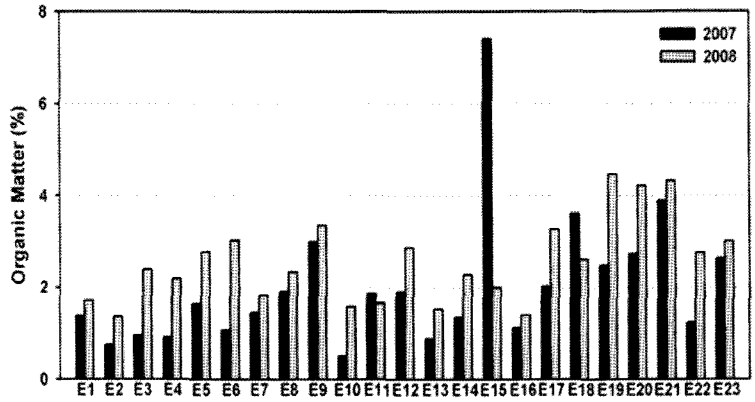


Fig. 8. Organic matter contents of soil from Dokdo in 2007-8 (above, Seodo; below, Dongdo).

were found in the soil in August 2007 than in April-June 2008, which is probably due to the fact that the population of black-tailed gulls in Dokdo is highest in August.

The substantial differences in the phosphoric acid contents of the soil among surveying points is undoubtedly related to differences in the rates at which soils are enriched with excrement from black-tailed gulls. For example, groups of black-tailed gulls live on points W4 and E22, which have little vegetation, and their excrement appears to have had a great influence on the phosphoric acid content at these sampling sites. In low pH soils, however, phosphorus combines with Fe, Al, Mn, and other minerals and changes into an almost insoluble form unavailable for plants, so the soluble phosphorus content in acidic soils is often low.

Contents of soil organic substances

Organic substances in the soil improve the air permeability and hygroscopicity of the soil and provide nutrients that plants need for growth. In general, humus soil that has 10-20% organic contents and is a good medium for plant growth. The organic substance content in the soil changes with soil temperature. At low temperatures, the rate of organic substance dissolution by microbes slows and organic acids accumulate, resulting in high soil acidity. The organic substance content in the soil is also closely related to forest succession. In the initial stages of forest succession, the organic substance content is relatively low, but the organic content of the soil tends to increase as forest succession progresses.

A 1990 survey found that soil on Dokdo had a 15% organic substance content (Lee 1990), and in the 2006 survey, the organic substance content of soil from Seodo was 3.6-14.0% and that of Dongdo was 1.70-37.88% (Gyeongsangbuk-do 2006). However, our 2007 and 2008 surveys found organic substance contents of soil from Seodo of only 0.6-7.8% and organic contents of soil from Dongdo of 0.5-7.4%, indicating a substantial drop in soil organic contents (Fig. 8). We believed that this drop can be attributed to loss or leaching of the soil resulting from higher rainfall in 2007 than in 2006.

Soil can be categorized by its organic substance contents. Generally, the organic contents of soil are considered 'Very High' for contents over 12%, 'High' for contents of 6-12% and 'Low' for contents of <3%. The average pH of forest surface soil in peninsular South Korea is 5.5 and its average organic substance content is 2.6% (Daegu city 1994, Huh et.al, 2005). On the other hand, the organic substance content of soil from Ulleungdo was very high, ranging from 17.9 to 28.9% in its topsoil. This is probably because Ulleungdo has a humid forest soil formed from volcanic ashes (Park et al. 2000). The average organic substance content of Dongdo and Seodo in 2007 and 2008 was around 3%, which is only slightly higher than that of forest soil on the Korean peninsula. Soil from sampling point W5 on Seodo, which was habitat for *Liriope platyphylla*, showed the highest organic substance content whereas soil from point E5 on Dongdo, which was inhabited by *Artemisia japonica* subsp. *littoricola*, had the highest organic substance content.

It also appears that the organic substance contents of soils on Dokdo are closely related to weather conditions, soil pH, and the amount and speed of decomposition of dead plants and black-tailed gull excrement.

CONCLUSION

According to the studies of Dokdo soil conducted so far, sea water scattered by strong winds and salts from dense sea fog have made the soil of Dokdo acid or weakly alkali. In addition, the ion contents, organic contents, nitrogen contents and phosphorus contents varied among locations and time periods, which may result from the distribution of plant species and biomasses on the islands, the distribution of birds, and the effects of sea wind, sea water, other physical and chemical characteristics of the soil, and rainfall. Since grassland vegetation covers most of Dokdo, the physical and chemical characteristics of Dokdo soil vary over time and space.

In conclusion, to better understand the basic physical and chemical features of the soil on Dokdo, it will be necessary to conduct long-term research on soil pH, ion contents, organic substances, nitrogen and phosphorus, and other chemical properties of the soil in addition to obtaining precise data from different soil depths. In particular, as the physical and chemical features of Dokdo soil may be affected by groups of birds such as black-tailed gulls, of which an estimated 12,000 individuals inhabit Dokdo, and *Oceanodroma monorhis*, which excavate holes in the ground. To better understand the effects of birds on soil characteristics, the relationship between movements of resident birds and soil properties on Dokdo must be monitored. Systematic and long-term research on the soil of Dokdo can help to predict future changes in the flora and vegetation of Dokdo and can provide fundamental data to inform conservation measures to protect the Dokdo ecosystem.

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