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THE SOIL PROPERTIES OF WOODLAND HAVING DIFFERENT GEOLOGICAL ORIGINS

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車鍾煥 : 各種地質의 林地에 含有된 土壤成分

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ABSTRACT

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In this experiment, the chemical components of the soils were collected from different horizons in some forest soils and naked soils developed on granite, crystalline schist, and granite gneiss were analized to be compared with each other.

The developed degree of the surface soils showed some difference according to the different geological formation. The soil derived from granite gneiss was showed to have more water content, available nitrogen, exchange properties and weathered most.

Much quantity of the organic matter, and of the available phosphorus was discovered in the soil derived from granite and found closely related to each other. The soil derived from the parent rock of granite showed highest acidity.

The soil derived on crystalline schist was found to have the maximum quantity of the nitrate nitrogen and the least of the exchange properties.

The only significant difference among the chemical properties of the three parent rock seems to be in the contents of the available phosphorus, nitrogen, water content, and organic matter in the Pinetum densiflorae, of the nitrogen, exchange properties, and pH in the Alnusetum japonicae, of the available phosphorus, nitrogen, total exchangeable base, and base saturation in the naked area, and of the nitrogen, base exchange capacity, and pH in all forest soils.

The degree of the distribution of the nutrient in soil was found decreasing going from the surface soil down to the subsoil.

INTRODUCTION

Of the cultivated and uncultivated soils of Korea, about 65% consist of soil developed from three parent materials of granite(24.25%), crystalline schist(10.32%), and granite gneiss(30.08%). These soils developed from the three parent materials have proved of great value in forestry silviculture. Many areas of the forest land are growing such trees as Pinus and Alnus, developing a thin, sparse vegetation.

Many earlier investigators have reported on the correlations between properties of soils and vegetation (12, 22, 18, 16, 14). Chandler et al(7), Coile(9), Ralston(17), and Coile et al(10) reported that the relation between the characteristic soil types and the growth of pine species by means of physical properties of forest soils. And the relation between the soil phosphate and the distribution of vegetation have reported by many investigators(1, 3, 19, 2, 8).

The topic of soil fertility arises often in discussions of forest growth, and much has been written for and against the value of chemical soil analyses in solving problems of tree growth ; yet not much is known about nutrient levels of specific sites. Also, with respect to most of these experiments, the relation between geological origin of forest soils and the growth of plants has been investigated by few workers, and have not been investigated as yet in Korea.

This paper reported here is designed to show the data on amounts and vertical distribution of the forms of the chemical elements for soils developed from the parent rocks of three different geological origins.

METHODS

The soils selected for the present investigation were collected from Mt. Kwan-ak at Shihung-ri (soils developed from the parent rock of granite gneiss) and at Dongjak-dong (soils developed from the parent rock of crystalline schist), and Mt. Sam-gak at Sooyu-ri (soils developed from the parent rocks of granite) in the regions in the vicinity of Seoul. The soil plots studied are the vegetation of the *Pinetum densiflorae* and the *Alnusetum japonicae,* and the unplanted areas of the soils developed from the three parent rocks (granite, crystalline schist, and granite gneiss). The soil samples were collected from four horizons (A_1, A_2, B_2, and C) of all types of soil under the forest types mentioned above and of all types of naked soils respectively. At each sample point a pit about 3 feet in diameter was opened to the depth at which the parent material was slightly showed. That is, soils were taken from each soil type of two forest soils and of the open areas of three different soils derived from the parent rock of geological origin in June 1963.

Chemical and physical analyses of soil samples were conducted according to the description in the earlier paper of these series(4,5).

The selected woodland sites were, as regards topography and vegetation, probably among the most uniform to be found in the Seoul region. Most of the observation for this study were obtained from the areas probably very similar to the other location with slight differences in direction, slope, and climatic variation. Altitude varied from 180 to 240m and annual rainfall from 1100 to 1400mm.

RESULTS

In Tables I, II, and III, the data of the chemical analysis of the soil samples obtained from under the parent rocks developed from different geological origins. The soil types of the stands investigated are of different geological origins, but the general range of chemical properties is broadly similar for all (Table I-III). However, available phosphorus contents of the various horizons of soil under different forest types developed on three geological origins varied greatly from O. Olppm to 1.20ppm. In spite of this large variation, there was appreciable similarity among the horizons of soil under the different forest types derived from different geological origins. The soils selected for the present study contain the generally low level of phosphorus. However, a similar value of phosphorus was reported by Johannessen(13) and also by the author's two previous papers(4,5). In each samples of soil developed from different geological origins, all the chemical components tended to reach a maximum in the surface soil and decreased some with increased depth in the profile. In all of the C horizon, that is, each nutrient tended to reach minimum except water content, but the other three horizons contained all the nutrients in maximum amounts in surface layers. These results might thus be produced by the leaching of nutrient ions or by the adding of organic matter from surface soil to subsoil. Small differences, both within forest types under soils derived from different parent rocks and in rates of change with depth from the surface to subsoil, may result partly from local site differences and partly from the tree species in the stands developed from different geological origins. As seen from the depth of the surface soil, derived from the parent rock of granite gneiss developed more than those of two different geological origins. Water content was only slightly different according to the soils and forest types. Organic matter varied over the region, being consistently higher in the soils developed from the parent rocks of granite and crystalline schist than in the soil developed from the parent rock of granite gneiss. The vertical distribution of organic matter and phosphorus in the soil is similar to that of available and nitrate nitrogen. Each nutrient decreased from surface to C horizon, and there were some differences at all depths within the forest and soil types. When hardwood and conifer stands are considered as separate groups, the average values of all nutrients at all depths of the mineral soils are similar. The reason for the phosphorus being so low in this study is mainly because the soil derived from the parent rock has less the addition of organic matter than the parent rock itself lacks the content of phosphate. Besides this, the difference of nutrient according to the parent rock is attributed to either the mutual relation of nutrient caused by the added amount in humus or the degree of development of the different forest soil. Phosphorus in the soil developed on granite is more abundant than those in the soil developed on crystalline schist and granite gneiss. A considerable part of phosphorus taken up by plants is derived from organic combinations; consequently, the decomposition cycle of the litter which falls annually is highly important. Usually, phosphorus and organic matter are closely correlated in the soil and the individual effects of the two factors on plant growth are therefore hard to separate. All the nutrients are usually more abundant in the surface soil, particularly if considerable organic matter is present. The exchange capacity and total exchangeable base in the soils developed from the parent rock of crystalline schist indicated less than those in the soils developed from two different parent rocks, whereas the content of nitrate nitrogen was shown to be greater in the soils developed from the parent rock of crystalline schist. In the soils developed from the parent rock of crystalline schist the amount of soil nitrate nitrogen is seen also to be slightly related with the amount of organic matter as has been generally observed in many other cases. According to Chandler(6) the exchange capacity is closely related to the organic content. The values of pH of the various soils showed remarkable uniformity ranging from 5.12 to 5.54, from 5.47 to 6.01, and from 5.44 to 5.93 in the soils developed from the parent rock of granite, crystalline schist, and granite gneiss, respectively. The pH-value of the soil developed from the parent rock of granite shows high acidity. This is because the parent rock is acidic.

Open, unplanted plots contain larger amounts of phosphorus and total exchangeable base in the soil developed on granite, available nitrogen in the soil developed on crystalline schist, and nitrogen in the soil developed on granite gneiss than forest stands. These higher values of chemical elements suggest that the unplanted plot may have chemical components added at some time or it had no chance to be absorbed by

Table I. The water content and organic matter of soils under different forest types developed on three geological origins.

Association	Horizons	Depth (cm)			Water content(%)			Organic matter(%)		
		*Gra.	C.S.	G.G.	Gra.	C.S.	G.G.	Gra.	C.S.	G.G.
Pinetum	A_1	0-5	0-4	0-7	2.24	2.21	2.75	1.74	1.33	0.99
densiflorae	A_2	5-26	4-29	7-37	2.24	2.56	3.61	1.06	1.17	0.79
	B_2	26-58	29-62	37-76	2.56	2.05	3.15	1.10	1.06	0.75
	C	58-	62-	76-	2.39	2.71	3.14	1.01	1.19	0.75
	Av.				2.36	2.38	3.16	1.38	1.19	0.82
Alnusetum	A_1	0-4	0-7	0-12	2.38	2.45	2.50	1.40	1.22	1.21
japonicae	A_2	4-26	7-36	12-45	2.45	2.39	2.55	1.14	1.02	1.02
	B_2	26-70	36-70	45-72	2.05	2.64	2.51	1.12	1.15	0.99
	C	70-	70-	72-	2.56	1.70	2.05	0.92	1.35	0.92
	Av.				2.36	2.30	2.40	1.15	1.19	1.04
Naked soils	A_1	0-4	0-5	0-5	2.75	1.00	3.32	1.65	1.21	1.08
	A_2	4-30	5-32	5-30	2.50	1.35	2.07	1.09	1.14	0.88
	B_2	30-58	32-56	30-52	2.32	2.32	2.05	0.89	0.91	0.97
	C	58-	56-	52-	2.69	2.05	1.89	1.00	1.02	0.63
	Av.				2.57	1.68	2.33	1.16	1.14	0.89

*Gra.: Granite C.S.: Crystalline Schist G.G.: Granite Gneiss

Table, II. Chemical properties of soils under different forest types developed on three geological origins.

Association	Horizons	Available phosphorus			Available nitrogen			Nitrate nitrogen			pH		
		Gra.	C.S.	G.G.	Gra.	C.S.	G.G.	Gra.	C.S.	G.G.	Gra.	C.S.	G.G.
Pinetum densiflorae	A_1	0.85	0.08	0.24	5.72	7.92	9.75	0.30	0.61	0.36	5.52	6.01	5.68
	A_2	0.90	0.02	0.13	5.51	8.50	8.45	0.33	0.55	0.38	5.49	5.69	5.66
	B_2	0.72	0.09	0.07	5.20	6.66	10.58	0.30	0.59	0.36	5.51	5.67	5.67
	C	0.02	0.02	0.07	5.37	7.05	8.12	0.28	0.58	0.34	5.50	5.79	5.67
	Av.	0.62	0.05	0.13	5.45	7.53	9.23	0.33	0.58	0.36	5.51	5.79	5.67
Alnusetum japonicae	A_1	0.28	0.16	0.16	6.85	9.23	9.84	0.49	0.58	0.30	5.49	5.80	5.93
	A_2	0.01	0.06	0.01	5.74	8.98	8.50	0.43	0.61	0.37	5.43	5.60	5.55
	B_2	0.01	0.05	0.02	4.40	8.52	8.18	0.39	0.60	0.43	5.15	5.47	5.56
	C	0.04	0.03	0.02	4.39	8.28	8.80	0.39	0.53	0.35	5.12	5.80	5.57
	Av.	0.09	0.08	0.05	5.35	8.75	8.83	0.43	0.58	0.36	5.30	5.67	5.65
Naked soils	A_1	1.20	0.07	0.04	5.60	11.04	9.40	0.38	0.45	0.43	5.20	5.80	5.62
	A_2	0.48	0.16	0.13	5.24	10.98	10.02	0.23	0.51	0.45	5.54	5.92	5.46
	B_2	0.92	0.10	0.02	5.55	7.32	10.78	0.18	0.47	0.42	5.35	5.80	5.44
	C	0.23	0.02	0.01	4.25	8.60	8.82	0.27	0.43	0.33	5.25	5.98	5.53
	Av.	0.71	0.09	0.05	5.16	9.49	9.76	0.27	0.47	0.41	5.34	5.88	5.51

Table III. The exchange properties of soils under different forest types on three geological origins.

Association	Horizons	Base exchange capacity(m.e.)			Total exchangeable base(m.e.)			Exchangeable hydrogen(m.e.)			Base saturation(%)		
		Gra.	C.S.	G.G.	Gra.	C.S.	G.G.	Gra.	C.S.	G.G.	Gra.	C.S.	G.G.
Pinetum densiflorae	A_1	45.78	41.40	45.10	19.50	16.50	19.03	26.28	24.90	26.07	42.60	39.86	42.20
	A_2	36.18	34.43	45.32	16.72	17.49	20.02	19.46	16.94	25.30	46.21	50.79	44.17
	B_2	36.93	39.93	43.12	17.69	13.97	18.59	19.24	25.96	24.53	47.90	34.98	43.11
	C	29.04	30.36	38.11	13.82	12.65	17.38	15.22	17.71	20.73	47.59	41.67	45.60
	Av.	36.98	36.53	42.91	16.93	15.15	18.76	20.05	21.38	24.16	46.08	41.83	43.77
Alnusetum japonicae	A_1	43.27	35.53	45.66	19.39	15.95	19.45	23.88	19.58	26.21	44.81	44.89	42.60
	A_2	48.50	29.28	45.43	18.92	11.46	19.58	29.58	17.82	25.85	39.01	39.13	43.10
	B_2	43.74	27.17	46.53	17.28	10.34	19.47	26.46	16.83	27.06	39.50	38.06	41.84
	C	45.67	26.93	42.43	18.00	9.79	18.59	27.67	17.14	23.84	39.41	36.35	43.79
	Av.	45.30	29.73	45.01	18.40	11.89	19.27	26.90	17.84	25.74	40.68	39.61	42.83
Naked soils	A_1	44.75	34.75	41.42	18.53	9.35	16.39	26.22	25.40	25.03	41.40	26.91	39.57
	A_2	43.10	28.98	48.90	24.26	11.88	19.69	18.84	17.10	29.21	56.29	40.99	40.27
	B_2	45.37	34.73	40.15	25.16	16.28	14.52	20.21	18.45	25.63	55.46	46.88	36.16
	C	43.54	34.40	35.64	22.12	12.98	13.64	21.42	21.42	22.00	50.80	37.73	38.27
	Av.	44.19	33.22	41.53	22.52	12.62	16.06	21.67	20.59	25.47	50.99	38.13	38.57

plants. The organic matter, phosphorus, and nitrogen levels recorded in these samples are almost all within the deficient categories by agricultural standards.

DISCUSSION

The geological origin of interest in this discussion is the crystalline schist (definitely terminology; biotite-plagioclase-schist), granite, and granite gneiss (definitely terminology; horblende-bearing biotite-quartz-plagioclase gneiss). The process weathered was probably very similar at the other location with slight difference in the parent material or in the time of original alteration. As described by Salisbury(20), the mechanism of formation of mature soil from the parent material of different geological origins may be important two factors. Extensive leaching would remove soluble calcium, iron, aluminum, and free sulphuric acid, and slightly soluble compounds such as gypsum are gradually dissolved by prolonged leaching. A second mechanism involves the addition of organic matter. Decay of organic matter would provide compounds which might chelate with iron and aluminum, and by some as yet unknown means nitrogen would be accumulated. Both of these mechanisms might operate simultaneously over long time intervals.

The data obtained in these experiments were tested statistically by the analysis of variance to draw the general conclusion(Table IV). According to the results of analysis of variance of the soil components under red-pine, the phosphorus, nitrogen, water content, and organic matter show the significance at the 1% and 5% levels of probability. The nitrogen, exchange properties, and pH-value show the significance according to the results of analysis of variance of the soil components under alder. The developed degree of the surface soils showed some difference according to the different plant communities and geological formation. The reason for the nutrient levels beings so low in this study is mainly because the herbaceous flora of these surface soil is extremely sparse. In fact, the absence of herbaceous and shrubby cover allows erosion of the mantle to be rapid and extreme. Salisbury(20) stated that analyses of surface soil samples supported the hypothesis that altered material develops a mature soil profile through a succession from the pines, Gambel oak,etc. to the big sage, rabbit brush, and pinon-juniper associations typical of the area. Such a succession would be marked by an increase in nitrogen and available soil phosphate, and a decrease in sulfate, iron, and aluminum. The significant difference among the chemical properties of the three parent rocks in the naked soils seems to be in the contents of the phosphorus, nitrogen, total exchangeable base, and base saturation. According to the results of analysis of variance among the chemical properties of the three parent rocks in all forest soils, the nitrogen, base exchange capacity, and pH-values were significant at the 1% and 5% levels of probability. The water content contained in each soil has certain points of similarity and the change caused by the soil profile or the species of the trees shows irregularity. The soil derived from parent rock of granite gneiss has less organic matter than the other soils. The relation between the base exchange capacity and organic matter is almost irregular, which is slightly against the results of the papers by Chandler(6), Whiteside et al(22), and previous papers(4,5). The soil derived from the parent rock of granite has more phosphorus content than the soils derived from the other two parent rocks. And more organic matter according to the decay of the fallen leaves was found in this soil. Such result suggests that the organic matter in soil contributes to phosphorus, which shows in agreement with the work of Lutz and Chandler(15). As seen from Table V, this result may suggest that the difference of nutrients in the soil derived from different geological origins can not depend on the difference of chemical properties of the parent rock itself. The soils derived from crystalline schist and granite gneiss have more available nitrogen than the soil derived from the parent rock of granite. The soil derived from the parent rock of crystalline schist has more nitrate nitrogen content than the soils from the other two parent rocks. According to Tayer's(21), nitrate nitrogen is an important factor in the establishment of Sitka spruce and Western hemlock seedling. In this study, however, the result shows no similar relationship. The naked soil derived from the parent rock of granite has especially small content of nitrate nitrogen. The soil in the region of the parent rock of crystalline schist shows low pH-value and the soil derived from the most acidic parent rock in the granite region the highest pH-value. The difference of exchange properties is irregular, but also varies according to the parent rocks, the species of the trees, and soil profile. And the base saturation of soils under each forest was different from others because soluble nutrients of each soil may be adsorbed differently and held temporarily among the solutions on the surface of the colloidal micelles, although the soils were developed from the same parent rock. The greatest concentration of exchange properties and chemical components in the surface mineral soil may result from the appreciable amounts of surface organic matter. The important factors which give influence on the difference of chemical components of the parent rocks derived from different geology are regarded as the weathering of the parent rocks, the decayed degree of the fallen leaves, and the developed degree of vegetation. The difference of the chemical components of the soil derived from the same parent rock shows no regularity in accordance with the species of the trees and the naked soil. It's not only because of the thin, sparse density of all trees but also of the lack of vegetation, and the small difference is probably mainly due to variations in the physical composition. In the present study, the general occurrence of a zone of minimum chemical components below the surface layers is the result of long-term effects of leaching in the parent materials of low chemical components, while high components in the surface soil reflect accumulated effects of deposition in plant materials. The frequent rise and fall of the water table in dry and wet seasons and the physical properties of the bottomland soil are the factors in the lack of chemical components in a lower horizon in the forest soils.

Table IV. Statistical analysese of the chemical properties given in Table(I-III).
(Values of the "F"-test among different geological origins of each forest soil).

	A-P	A-N	N-N	W-C	O-M	B.E.C.	T.E.B.	E-H	B-S	pH
Pinetum densiflorae										
F-Values	*6.62	**16.0	**77.2	**10.20	**13.8	1.73	3.02	0.25	0.43	0.33
L.S.D.	0.38	1.51	0.05	0.45	0.15					
Alnusetum japonicae										
F-Values	0.13	**11.67	**22.72	0.17	0.05	**31.9	**22.0	**28.80	1.56	*6.45
L.S.D.		0.88	0.08			5.06	2.55	2.93		0.27
Naked soil										
F-Values	**7.68	**16.25	**9.09	2.30	1.04	1.18	**9.79	2.91	*5.31	3.74
L.S.D.	0.43	1.98	0.11				5.05		10.35	
♯All forest soils										
F-Values	1.90	**16.05	*6.08	1.27	2.68	*7.79	1.33	3.33	2.33	**12.9
L.S.D.		1.79	0.12			6.71				0.21

** : Significant at the 1% level. * : Significant at the 5% level.

♯All forest soils : Values of the "F"-test among different geological origins.

A-P : Available phosphorus
A-N : Available nitrogen
N-N: Nitrate nitrogen
W-C : Water content
O-M: Organic matter
B.E.C.: Base exchange capacity
E-H : Exchangeable hydrogen
T.E.B.: Total exchangeable bases
B-S : Base saturation

Table V. The values of chemical analyses of the three rocks(in Mt. Sam-gak, and Mt. Kwan-ak)*

	Granite	Crystalline schist	Granite gneiss
SiO_2	68.81%	55.44%	61.47%
TiO_2	0.25	1.05	0.65
Al_2O_3	17.56	18.17	19.63
Fe_2O_3	0.85	1.73	1.60
FeO	0.01	4.71	2.37
MnO	0.14	0.67	0.07
MgO	0.49	4.04	1.26
CaO	3.50	7.26	4.66
Na_2O	3.50	3.25	4.85
K_2O	2.87	1.42	2.16
P_2O_5	0.16	0.24	0.14
H_2O^+	1.65	1.37	0.94
H_2O^-	—	0.39	0.16
Total	99.79	99.74	99.96

*These dada were obtained from the geological survey institude of Korea.

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摘 要

本 實驗은 韓國 地質의 大部分을 占領하고 있는 花崗岩, 結晶片岩, 花崗片麻岩에서 誘導된 소나무 및 오리나무群落의 林地와 裸地의 여러 土層으로부터 採取한 土壤의 化學成分을 서로 分析 比較하였다. 土層의 發達程度는 各 地質의 形成에 따라 若干의 差異가 있고 花崗片麻岩의 誘導 土壤이 水分含量, 有效窒素, 置換能等을 많이 보이고 가장 風化되었다. 有機物과 有效燐酸의 많은 含量은 花崗岩의 誘導 土壤에서 發見되었고 이들은 서로 密接한 關係를 나타냈다. 또한 이 土壤이 가장 높은 酸性을 보였다. 結晶片岩에서 誘導된 土壤은 硝酸態窒素의 含量이 가장 많으며 置換能이 가장 적었다. 세 母岩의 化學成分사이에 有意差가 소나무群落에서는 有效燐酸, 窒素, 水分含量, 有機物 含量等에서 오리나무群落에서는 窒素, 置換能, pH等에서, 裸地에서는 有效燐酸, 窒素, 全置換鹽基 및 鹽基飽和等에서 그리고 全 林土에서는 窒素, 鹽基置換能 및 pH等에서 나타났다. 土壤內에 養分의 分布 程度는 表土로부터 下層土로 내려 갈수록 減少되었다. 이는 筆者의 前報(4, 5)와 같은 結果이다.

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