EXTRACTABLE CALCIUM, MAGNESIUM, POTASSIUM AND SODIUM IN DIEFFERENT PEAT TYPES

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According to the common view peat types in which remains of *Carex* or *Bryales* dominate are of a better quality than those mainly composed of *Sphagnum* species. Thus within the Finnish classification in which the moss peats are divided into *Sphagnum* peat (Sp) and *Carex-Sphagnum* peat (CSp), and the fen peats into *Sphagnum Carex* peat (SCp), eutrophic *Sphagnum-Carex* peat (EuSCp), *Carex* peat (Cp) and *Bryales-Carex* peat (BCp), the quality of the peat is supposed to improve in this order. This, however, is not always the case when results of peat analyses are examined a marked variation within a certain peat group both in the nutrient content and other characteristics may be established (c.f. KIVINEN 1933, KAILA et al. 1954, KAILA 1956 b). The differences between the mean values are often significant, but the individual data of one group are almost always overlapping the corresponding range of the other groups.

It was not likely to obtain markedly differing results when the cation content of various peat types was chosen as the object of the present study. In most of the papers dealing with the nutrient content of peat only the total amounts are reported. Yet, the authors found it desirable to get more information of the plant-available calcium, magnesium, and potassium in samples of virgin peat soils.

The problem of the availability of these nutrients to plants was conventionally solved. Considering the fact that the samples were air-dried and ground the results obtained by any method are likely to yield only an approximate estimate of the plant-available amounts under the natural conditions. Therefore, instead of the usual determination of exchangeable cations by washing with barium acetate the analytically more convenient extraction with ammonium chloride was employed.

Material and methods

The material of the present study was partly the same as in a previous work (KAILA 1956 b). It consisted of 208 samples of virgin peat soils collected mostly from Northern Finland. The samples originated both from the surface and the deeper layers.

The peat type and the degree of humification were estimated by direct examination of the fresh samples in the field. All the other analyses were performed using samples which were air-dried and ground in a Wiley mill. The soil pH was determined in water suspension (1: 4) by a Beckman pH-meter with glass electrode. The volume weight was measured with an apparatus developed in this laboratory (cf. KAILA 1956).

The determination of the extractable cations was performed shaking 5 g samples of peat in 100 ml of 1 N ammonium chloride for two hours. The suspension was filtrated through paper without washing. Calcium, potassium and sodium in the filtrate were determined using a flame photometer by Lange. Magnesium content of the filtrate was calculated as the difference between the total calcium and magnesium content estimated by the versenate titration (CHENG and BRAY 1951) and the calcium content obtained in the flamephotometric way.

Origin and quality of the samples

The results are reported in Table 1. The title »Bog type» means peat land vegetation type. The letter R = »räme» or pine bog, N = »neva» or treeless oligotrophic bog, K = »korpi» or spruce-broadleaved tree swamp, and L = »letto» or rich treeless fen. The column titled »Bo» represents the degree of land quality, estimated on the basis of the surface vegetation. The grading from 1 to 10, common in Finnish soil survey, is used. The classes from 5 to 10 are generally considered tillable.

There are 32 samples of Sp from treeless oligotrophic bogs or pine bogs with a low degree of land quality. The origin of the 31 samples of CSp is not markedly better. A large part of the 59 SCp-samples were collected from tillable peat lands, but among them are also samples particularly from the deeper layers of peat lands with a poor surface vegetation. Only 7 samples of EuSCp were available, all of them from rich treeless fens as well as all the 33 samples of BCp. The origin of the 46 samples of Cp is variable: several of them represent deeper layers of peat lands with a poor surface vegetation.

Owing to the fact that a large part of the moss peat samples originates from layers of a lower depth than those of the fen peats tend to do, also the degree of humification in the former samples appears to be lower than that in the latter ones. This may be illustrated by the mean values of the sampling depth and the degree of humification computed for the different peat groups. These were the following: (as a measure of variation the confidence limits at 95 % level are given):

	Depth dm	H	Correlation coefficient between depth and H
32 Sp samples	3.3 ± 1.1	2.7 ± 0.7	0.695***
31 CSp »	4.4 ± 1.2	3.6 ± 0.6	0.391*
59 SCp »	5.0 ± 2.8	4.0 ± 1.6	0.548***
7 EuSCp »	8.9 ± 3.8	4.7 ± 1.6	0.772
46 Cp »	9.0 ± 1.8	5.2 ± 0.5	0.473**
33 BCp »	7.8 ± 2.5	3.8 ± 0.6	0.163

Table 1. Calicium, magnesium, potassium and sodium extracted by 1 N ammonium chloride from virgin peat samples.

No	Bog type	Bo	Depth dm	H	pH	Weight of volume	Ca	Mg	K	Na
							p.p.m.			
				Samples of Sp						
65	N	2	0—2	1	3.7	0.05	1800	1500	930	400
144	R	1	0—2	1	5.1	0.07	950	1900	550	120
K 31	N	1	0—2	1	4.2	0.08	4100	1100	190	120
K 32	N	1	4—6	1	4.4	0.08	4700	900	100	300
K 21	N	2	0—2	1	4.3	0.09	6200	700	200	30
K 34	N	2	0—2	1	4.2	0.09	3400	900	200	20
A 4	R	1	3—5	1	4.7	0.10	2800	1200	200	100
K 37	N	1	0—2	1	4.5	0.11	4900	1400	600	20
K 6	R	2	1—2	1	4.5	0.11	7000	400	1000	400
A 27	N	2	0—2	1	4.5	0.12	2000	1400	40	40
36	R	2	0—2	1	4.0	0.12	2000	1800	500	40
A 58	N	1	1—3	1	3.8	0.13	1580	900	200	50
A 37	N	2	0—2	1	4.4	0.28	3200	1400	700	40
A 31	R	2	0—2	1	3.9	0.29	2100	1700	250	10
K 22	R	1	2—4	2	5.0	0.14	10600	4000	400	30
K 7	R	2	2—3	2	4.6	0.17	6800	400	800	400
V 6a	N	1	1—3	2	4.9	0.22	4300	1600	200	230
66	N	2	2—5	3	3.6	0.09	2300	1200	200	150
A 5	R	1	5—7	3	4.9	0.23	3500	1600	100	100
V 6b	N	1	5—7	3	5.1	0.26	4600	2100	100	160
A 1	R	1	2—3	3	3.7	0.29	3200	800	100	20
A 32	R	1	3—5	3	4.0	0.34	1500	900	50	10
A 6	R	1	12—14	4	4.7	0.21	7100	3600	100	100
V 1 a	N	3	1—3	4	4.3	0.31	1700	900	200	50
V 15 a	N	1	1—3	4	4.5	0.33	2200	950	140	90
105	R	2	0—2	4	4.4	0.20	5800	330	150	120
V 1 b	N	3	5—7	4	4.3	0.33	1500	800	100	50
67	N	2	5—9	5	3.8	0.21	1700	800	130	110
A 2	R	1	3—4	5	3.8	0.49	3600	1100	100	20
V 15 b	N	1	5—7	6	4.4	0.41	3600	850	50	80
68	N	2	9—11	7	4.2	0.32	1800	900	90	40
A 3	R	1	7—10	7	4.4	0.38	5600	1700	50	30
				Samples of CSp						
V 24 a	N	2	1—3	1	4.5	0.10	2400	1200	100	190
V 23 a	N	2	1—3	1	4.5	0.11	1700	1400	100	120
V 16 a	N	3	1—3	1	4.4	0.12	3800	2000	410	280
69	R	2	0—2	2	4.2	0.09	2300	2200	2600	240
V 2 a	N	3	1—3	2	4.3	0.15	2400	1200	450	60
K 38	N	1	2—4	2	4.6	0.23	4300	750	360	40
107	N	3	0—2	3	4.4	0.16	2000	2900	160	120
V 24 b	N	2	5—7	3	4.8	0.17	800	1000	50	90
V 23 b	N	2	5—7	3	4.9	0.19	1500	600	30	10

1	2	3	4	5	6	7	8	9	10	11
28	N	3	4—6	3	4.2	0.23	2100	750	40	20
37	N	2	0—2	3	4.7	0.33	2800	1400	300	500
A 52	N	2	1—3	3	3.8	0.33	1530	430	210	100
K 39	N	1	4—6	3	4.6	0.25	3500	540	130	10
V 21 a	N	3	1—3	3	5.0	0.30	3900	1800	80	120
V 21 b	N	3	5—7	3	5.2	0.28	3400	1600	50	120
A 28	N	2	5—7	4	4.3	0.30	1600	1100	10	30
70	R	2	3—5	4	4.4	0.25	1730	1500	640	1340
V 16 b	N	3	5—7	4	4.5	0.29	2300	1200	100	100
V 22 b	N	3	5—7	4	5.1	0.28	3500	1600	60	100
V 2 b	N	3	5—7	4	4.2	0.31	1950	860	290	50
34	N	3	0—2	4	4.5	0.34	1300	1200	300	50
V 22 a	N	3	5—7	4	4.7	0.37	3100	1600	260	160
35	R	3	0—2	4	4.5	0.38	2600	1300	300	70
K 8	R	2	3—4	5	4.6	0.39	3900	190	270	100
K 33	R	1	6—8	5	4.5	0.25	4400	900	60	20
29	N	3	15—20	5	5.1	0.33	4400	1000	30	30
A 29	N	2	8—10	5	4.1	0.35	1800	1200	20	10
106	N	7	0—2	6	4.7	0.26	5600	2000	320	430
71	R	2	7—10	6	4.3	0.36	1180	1180	180	410
K 42	R	2	2—4	6	3.9	0.39	3000	260	1350	220
A 46	R	2	4—6	7	4.1	0.49	2200	600	80	50
					Samples of SCp					
K 28	N	1	0—3	1	4.5	0.20	4500	1000	50	90
V 3 a	N	3	1—3	1	4.4	0.14	2900	2000	200	50
A 19	N	2	0—2	2	5.0	0.25	6000	1700	410	170
A 12	N	3	3—5	2	4.8	0.25	4600	1800	80	50
A 13	N	3	8—10	2	4.8	0.20	3800	1900	170	50
A 23	N	2	1—3	2	4.7	0.38	4400	1400	280	50
V 19 a	N	5	1—3	2	4.7	0.21	4600	2200	370	230
V 5 a	N	4	1—3	3	4.6	0.24	4000	1000	60	40
K 12	N	4	0—1	3	4.4	0.27	5100	1300	160	130
A 53	N	2	1—3	3	4.2	0.42	1100	300	70	50
59	N	5	0—2	3	3.6	0.23	1600	2100	610	250
A 47	R	2	2—4	3	4.6	0.23	2400	1200	120	160
V 3 b	N	3	5—7	3	4.3	0.25	2400	1200	60	50
V 30	N	5	2—3	3	5.1	0.26	3800	1200	130	40
A 11	N	3	0—2	3	4.9	0.26	2400	1100	180	30
A 16	N	2	6—8	3	4.5	0.30	1800	1300	20	30
V 5 b	N	4	5—7	3	4.9	0.30	4500	1100	60	50
A 35	N	6	0—4	3	5.5	0.31	13200	4700	260	30
V 10 b	N	3	5—7	3	4.9	0.24	1800	1600	180	150
V 9 b	N	3	5—7	3	4.9	0.24	1800	1200	90	170
V 13 a	N	4	1—3	3	4.4	0.25	1800	1200	200	190
K 18	N	4	0—2	3	5.5	0.27	3300	700	60	20
V 9 a	N	3	1—3	3	4.9	0.27	1900	1200	140	150
V 10 a	N	3	1—3	3	4.7	0.27	1700	1200	250	190
V 14 a	N	4	1—3	4	4.5	0.29	1500	1300	190	60
V 20 a	N	5	1—3	4	4.6	0.33	3000	1600	250	100

1	2	3	4	5	6	7	8	9	10	11
K 24	R	1	6—8	4	5.1	0.35	6600	1300	110	20
A 49	N	5	1—3	4	4.3	0.34	2700	500	350	290
V 11 b	N	3	5—7	4	4.8	0.24	1600	1700	60	120
V 8 a	N	4	1—3	4	4.7	0.25	1400	1000	230	70
V 26	N	5	2—3	4	5.0	0.26	4800	1800	110	40
V 11 a	N	3	1—3	4	4.7	0.28	1700	1000	180	150
33	N	6	0—2	4	4.7	0.30	2700	1500	490	60
A 20	N	2	4—6	4	4.2	0.30	2900	1400	110	50
V 12 a	N	4	1—3	4	4.4	0.30	1600	1100	190	150
V 17 a	N	4	1—3	4	4.8	0.30	3400	1400	130	200
V 17 b	N	4	5—7	4	4.9	0.30	3100	1600	50	90
V 18 a	N	4	1—3	4	4.8	0.32	3000	1000	200	120
V 18 b	N	4	5—7	4	4.9	0.31	3300	1600	70	70
A 15	N	2	2—4	4	4.3	0 34	2100	1100	130	30
V 8 b	N	4	5—7	4	4.9	0.25	1700	1400	60	170
V 7 a	N	6	1—3	5	4.7	0.29	1200	1000	240	70
A 33	N	2	8—10	5	4.1	0.30	1300	700	350	0
60	N	5	3—9	5	3.5	0.32	1700	2100	250	190
K 35	R	3	4—6	5	4.9	0.34	3400	900	180	20
V 31	N	5	4—6	5	5.1	0.35	6000	1000	70	100
V 27	N	5	4—6	5	5.2	0.37	5600	1900	50	90
K 23	R	1	4—6	5	5.0	0.32	7900	2200	190	20
K 59	N	4	0—5	5	5.3	0.34	3000	400	90	60
V 19 b	N	5	5—7	5	5.1	0.39	4100	1700	70	200
V 32	N	5	8—10	6	5.2	0.37	9700	1900	80	60
V 28	N	5	8—10	6	5.3	0.40	6400	2300	40	60
V 14 b	N	4	5—7	6	4.5	0.40	2400	1000	50	290
V 13 b	N	4	5—7	6	4.5	0.40	2000	1400	80	100
V 12 b	N	4	5—7	6	4.4	0.40	2000	1400	70	60
V 20 b	N	5	5—7	6	5.5	0.42	5200	2100	60	120
61	N	5	10—13	7	4.2	0.40	1900	1800	120	360
V 7 b	N	6	5—7	7	5.0	0.40	730	1200	110	150
76	R	1	60	9	4.8	0.71	4400	3100	60	130
				Samples of EuSCp						
62	L	8	0—2	3	4.4	0.18	3400	3500	1600	430
40	L	8	0—2	3	5.6	0.25	14000	5060	690	1930
K 5	L	8	4—6	3	5.4	0.27	14000	2950	420	310
63	L	8	6—8	5	4.7	0.32	9550	2340	170	210
117	L	8	17—20	6	5.2	0.41	13100	4500	80	250
118	L	8	20—23	6	5.4	0.47	12400	4000	30	200
64	L	8	8—10	7	4.3	0.38	5200	2370	120	160
				Samples of Cp						
K 29	N	4	5—7	2	4.6	0.20	3700	820	360	360
A 41	N	3	3—5	3	4.8	0.25	2400	1200	50	60
A 43	N	3	2—6	3	4.5	0.24	3000	1300	80	130
A 40	N	3	0—2	3	4.7	0.30	3550	1360	280	50
A 38	N	2	3—5	3	4.5	0.29	2100	860	190	30
A 8	K	5	0—2	3	4.7	0.32	3970	820	10	20

1	2	3	4	5	6	7	7	9	10	11
A 24	N	2	5—6	3	5.0	0.34	3700	1700	20	10
K 25	N	6	1—3	3	4.6	0.21	3400	850	30	10
K 26	N	6	5—7	3	4.2	0.20	3500	1400	30	10
K 14	N	4	5—7	3	5.1	0.26	3400	1100	10	20
K 13	N	4	1—3	3	4.9	0.28	3900	1100	20	20
38	K	7	0—2	4	4.9	0.36	6800	2680	560	490
K 27	K	6	11—14	4	4.4	0.23	2900	1400	30	10
109	N	6	0—2	4	4.6	0.24	1300	660	660	280
111	K	6	0—2	4	4.7	0.26	2700	1200	50	120
103	N	4	0—2	4	4.8	0.28	3200	1350	300	320
A 44	N	3	6—8	4	4.3	0.27	3300	1350	100	120
A 42	N	3	8—10	4	4.9	0.23	2700	1200	100	110
110	N	6	0—2	4	4.6	0.24	2800	1200	50	100
47	N	6	4—6	5	5.2	0.32	12200	1700	210	510
48	N	6	7—10	5	5.4	0.36	12100	1900	170	190
A 17	N	2	8—10	5	4.1	0.31	2000	1050	210	40
K 36	N	2	4—6	5	4.9	0.34	3700	1100	60	10
K 41	R	4	2—6	5	4.2	0.28	3900	1130	1400	430
K 30	R	4	2—5	5	4.8	0.34	3600	510	80	30
49	N	6	12—15	6	5.6	0.38	12900	2600	200	160
50	N	6	17—20	6	5.5	0.39	14300	3000	170	540
104	N	6	0—2	6	4.6	0.29	2300	1500	270	80
K 20	N	4	6—8	6	5.4	0.30	3800	1300	20	10
131	L	8	27—30	6	5.0	0.35	7600	3100	60	390
A 25	N	2	8—9	6	5.1	0.37	4100	1700	20	10
138	L	8	20—23	6	5.5	0.43	20000	3300	130	200
K 4	N	6	3—6	6	5.2	0.35	13500	2900	410	150
51	N	6	22—25	7	5.6	0.50	14800	3200	210	850
52	N	6	32—35	7	5.8	0.47	19800	4100	120	850
53	N	6	37—40	7	5.6	0.48	22400	4100	180	1160
54	N	6	42—45	7	5.3	0.44	15200	5200	150	1010
A 21	N	2	8—10	7	5.8	0.37	9000	4600	90	30
137	L	8	17—20	7	5.6	0.39	19400	3400	60	250
A 50	N	3	3—5	7	4.6	0.31	2100	510	100	100
31	K	6	3—6	7	4.9	0.39	13400	2900	130	690
K 19	N	4	3—5	8	5.4	0.46	3400	710	20	10
30	K	6	0—3	8	4.6	0.54	13200	3600	250	520
32	K	6	0—5	8	4.7	0.69	7700	7600	500	140
A 45	N	3	12—14	8	4.9	0.52	2900	1150	80	50
K 60	N	4	.10—14	8	4.9	0.53	3550	1180	50	40
				Samples of BCp						
K 9	L	7	0—2	1	4.9	0.16	5200	900	300	200
K 1	L	7	0—2	1	5.5	0.14	10500	1100	300	400
K 10	L	7	2—4	2	5.2	0.24	3700	400	100	100
74	L	7	0—2	2	6.2	0.20	13300	3000	70	140
122	L	8	14—17	2	4.9	0.22	8100	3500	50	200
139	L	8	0—2	2	3.9	0.48	4400	2200	300	200
39	L	7	0—2	3	4.7	0.23	4300	1500	200	100
119	L	8	4—7	3	5.1	0.30	5900	2700	50	100

1	2	3	4	5	6	7	8	9	10	11
120	L	8	7—10	3	5.0	0.25	7900	3000	50	300
121	L	8	10—13	3	4.8	0.21	9000	3400	50	200
129	L	8	20—23	3	4.8	0.27	10000	3400	50	200
143	L	7	0—2	3	4.1	0.21	3200	2000	70	210
113	L	8	4—7	3	5.6	0.28	13500	4300	50	200
126	L	8	10—13	3	4.9	0.25	7600	3300	50	100
127	L	8	14—17	3	4.9	0.24	8700	3400	50	200
128	L	8	17—20	3	4.8	0.25	8800	3400	50	200
K 2	L	7	3—5	3	5.2	0.28	8600	1100	300	300
73	L	8	0—2	3	8.0	0.44	23500	4000	80	210
125	L	8	4—7	4	4.9	0.30	7300	4100	70	150
123	L	8	17—20	4	4.9	0.24	8600	3000	50	300
114	L	8	7—10	4	5.4	0.29	13000	4100	100	200
141	L	7	0—2	4	5.6	0.45	14000	5100	200	270
75	L	7	0—2	4	5.4	0.24	10200	3500	30	120
130	L	8	24—27	5	5.0	0.36	8200	3400	50	200
142	L	8	0—2	5	4.8	0.53	11700	4000	360	220
115	L	8	10—13	5	5.4	0.37	12700	4100	50	200
135	L	8	10—13	6	5.8	0.44	13800	4000	100	200
116	L	8	14—17	6	5.3	0.39	12000	4100	50	200
140	K	10	0—2	6	5.1	0.58	14700	2200	200	300
134	L	8	4—10	6	5.7	0.43	11500	3400	100	200
136	L	8	14—17	7	5.7	0.42	15000	4500	100	200
K 3	L	7	7—9	7	5.3	0.34	6800	700	200	100
K 11	L	7	5—7	7	5.0	0.37	4000	700	10	200

In this material distinct differences exist between the peat groups both in the degree of humification and in the sampling depth. It is worth noticing that in the BCp-group the average degree of humification is markedly lower than on the basis of the average sampling depth it could be supposed to be. In all the other peat groups the degree of humification tends to grow with the depth, although the total correlation coefficient between these quantities does not always appear to be very high.

In any case there are reasons to pay attention to this difference in the quality of the samples of the different peat groups when the results of this study are examined. It was found in connection with a previous work (Kaila and Kivekäs 1956) that in peat soil profiles generally a large part of extractable potassium is accumulated in the surface layers. The magnesium content, on the other hand, tended to be higher in the deeper layers.

Extractable cations in the peat samples

In Table 1 the amounts of cations extracted by 1 N ammonium chloride solution are reported as parts per million of the dry matter. According to the authors' opinion it is not justified to suppose that the results obtained by the present method would correspond to the exchangeable cations. Therefore, the results have not been reported as milliequivalents per 100 g.

In order to get a better survey of the data in Table 1, the means for the cation contents in the different peat groups were computed. Also the cation content expressed on the volume basis was calculated. This quantity does not, of course, correspond to the real amounts of these nutrients as kg/ha in the natural peat layers of a depth of 20 cm. Yet, it may be supposed to give a relative estimate of the amounts of these extractable cations.

First the means of the calcium content in the different peat types are examined. In addition to the means with their confidence limits at 95 per cent level also the minimum and maximum values are reported.

	Ca p.p.m.		Ca kg/ha	
	mean	min. — max.	mean	min. — max.
Sp (32)	3 690 ± 720	950 — 10 600	1 460 ± 360	130 — 4 260
CSp (31)	2 680 ± 850	800 — 5 600	1 460 ± 330	270 — 3 040
SCp (59)	3 410 ± 590	730 — 13 200	2 160 ± 270	590 — 8 190
EuSCp (7)	10 240 ± 4 090	3 400 — 14 000	6 890 ± 2 670	1 230 — 11 660
Cp (46)	7 070 ± 1 780	1 300 — 22 400	5 530 ± 1 090	630 — 21 510
BCp (33)	9 720 ± 1 510	3 700 — 23 500	6 510 ± 1 670	1 660 — 20 680

According to these means there appears to be a distinct difference between the groups of Sp, CSp, and SCp and the groups of EuSCp, Cp and BCp. Thus in this material the SC-peat, generally counted among the fen peats, resembles more the moss peats known to be poor in calcium. In the material studied by KIVINEN (1933) the average content of total calcium in the different peat types was of the same order as in this paper the respective data for calcium extracted by 1 N ammonium chloride. The mean values reported by KIVINEN for calcium dissolved by 1 % citric acid were generally somewhat lower than our data, and the Cp group was surprisingly poor in calcium.

The mean quantities of magnesium extracted by the present method were the following:

	Mg p.p.m.		Mg kg/ha	
	mean	min. — max.	mean	min. — max.
Sp (32)	1 310 ± 250	330 — 4 000	530 ± 150	90 — 1 290
CSp (31)	1 240 ± 200	190 — 2 900	610 ± 120	200 — 1 190
SCp (59)	1 460 ± 190	300 — 4 700	920 ± 160	250 — 4 400
EuSCp (7)	3 540 ± 1 180	2 340 — 5 060	2 480 ± 1 010	1 500 — 3 760
Cp (46)	2 010 ± 440	510 — 7 600	1 600 ± 520	320 — 10 490
BCp (33)	2 950 ± 460	400 — 5 100	1 960 ± 590	190 — 4 590

The variation in the magnesium content is marked as it also was in the calcium content. In regard to the magnesium content the SCp group belongs to the moss peats, although less distinctly than in regard to the calcium content.

Now, of course, arises the question whether the difference in the sampling depth plays any part in these results. The SCp samples were, on the average, collected from layers which were far less deep than were the layers from which the Cp, EuSCp and BCp samples originated. In the mean degree of humification, on the other hand, the differences between SCp samples and samples of the BCp and EuSCp groups are insignificant. The correlation coefficients between the cation contents and the degree of humification or of the sampling depth are the following:

	Cap.p.m.		Mg p.p.m.	
	Depth	H	Depth	H
Sp (32)	0.113	— 0.020	0.375	— 0.078
CSp (31)	0.330	0.149	— 0.269	— 0.279
SCp (59)	0.048	0.052	0.357**	0.114
EuSCp (7)	0.281	— 0.165	0.026	0.409
Cp (46)	0.568***	0.393**	0.528***	0.652***
BCp (33)	— 0.012	0.275	0.320	0.216
All (208)	0.398***	0.198*	0.433***	0.219*

These total correlation coefficients do not reveal any connection between the calcium or magnesium content and the depth or the degree of humification, except in the Cp-group. The fact that the samples of Cp, BCp and EuSCp groups generally originated from deeper layers and contained higher amounts of these extractable cations is probably the reason for the significant correlations between the depth and the calcium and magnesium contents in all the material. As to the connection between the cation contents and the degree of humification only a low correlation can be demonstrated. Consequently, the differences found in the mean contents of calcium and magnesium in the various peat types probably do not arise only from the differences in the sampling depth.

The amounts of potassium extracted by 1 N ammonium chloride from these samples were far lower than those of calcium and magnesium. In connection with some other work it was found that almost all of the potassium in this kind of peat samples was extracted by the present method. This is in accordance with what is known of the occurence of potassium in peat soils.

The mean content of potassium in the different peat types of this material was the following (the means expressed with the confidence limits at 95 per cent level):

	K p.p.m.		K kg/ha	
	mena	min. — max.	mean	min. — max.
Sp (32)	260 ± 100	40 — 1 000	90 ± 30	10 — 390
CSp (31)	300 ± 180	10 — 2 600	140 ± 70	5 — 1 050
SCp (59)	160 ± 30	40 — 610	90 ± 15	10 — 300
EuSCp (7)	440 ± 500	30 — 1 600	210 ± 180	30 — 580
Cp (46)	180 ± 70	10 — 1 400	130 ± 55	5 — 790
BCp (33)	110 ± 30	30 — 300	80 ± 30	10 — 380

The variation in the potassium content is high in all the peat groups. Generally it appears to be even higher than the corresponding variation in the calcium and magnesium content. Although no significant difference can be noticed between the mean values for the peat groups, a slight tendency to higher potassium content may be observed in the moss peats or groups of Sp and CSp as compared with the groups of BCp, Cp, and SCp. Some high numbers in the EuSCp group heighten the mean of these few samples. Probably the conclusion which can be drawn on the basis of these data is that there are no distinct difference in the content of extractable potassium in the peat types.

The amounts of sodium extracted by the present method also varies markedly within all the groups. The values are of the same order as those of potassium, and mostly far lower than the calcium and magnesium contents. The mean values and the variation limits for sodium are the following:

	Na p.p.m.		Na kg/ha	
	mean	min. — max.	mean	min. — max.
Sp (32)	100 ± 30	10 — 400	30 ± 10	5 — 135
CSp (31)	170 ± 90	10 — 1 340	90 ± 50	5 — 670
SCp (59)	110 ± 30	0 — 360	80 ± 30	0 — 405
EuSCp (7)	490 ± 600	160 — 1 930	280 ± 280	120 — 970
Cp (46)	230 ± 90	10 — 1 160	180 ± 90	5 — 1 115
BC (33)	200 ± 20	100 — 300	130 ± 25	5 — 350

The Sp and SCp groups are fairly low in extractable sodium. Also the CSp-samples contain less sodium than the EuSCp, Cp, and BCp groups, particularly as expressed on the volume basis. It looks as if the relations between the sodium content of these peat groups would be more like those of calcium content than those of potassium.

The connection between the depth or the degree of humification and the amounts of extractable potassium or sodium in the different peat groups were calculated and the following total correlation coefficients were obtained:

	K		Na	
	Depth	H	Depth	H
Sp (32)	— 0.566***	— 0.484**	— 0.254	— 0.217
CSp (31)	— 0.331	— 0.074	— 0.115	0.087
SCp (59)	— 0.205	0.207	0.047	0.191
EuSCp (7)	— 0.709	— 0.728	— 0.538	— 0.574
Cp (46)	— 0.211	— 0.029	0.696***	0.406**
BCp (33)	— 0.222	0.074	— 0.205	0.051
All (208)	— 0.211*	— 0.187*	0.249**	0.144

It was found in a previous paper (Kaila & Kivekäs 1956) that the content of extractable potassium in peat soil profiles tends to be higher in the surface layers than in the deeper ones. In this material a significant correlation between the sampling depth and the potassium values exist only in the Sp-samples. The very slight connection for all the material does not tell whether the differences in the sampling depth have any effect on the amounts of potassium in the samples of the different peat groups. The same holds true with the connection between potassium content and the degree of humification.

The latter characteristic is not at all correlated with the content of extractable sodium in these samples, except in the Cp-group. In this group also a high correlation with depth can be noted, the reason of which is not clear.

Extractable cations and acidity of the samples

It is a common knowledge that the composition of the cation system in the soil is the factor on which the acidity of the soil mostly depends. The authors found it desirable to study the relation of the content of these extractable cations and the soil reaction.

In this material the pH-values measured in a water suspension of air-dried samples were, on the average, the following for the various peat groups:

Sp:	pH 4.3 ± 0.2	CSp:	pH 4.5 ± 0.1	SCp:	pH 4.7 ± 0.1
EuSCp:	pH 5.0 ± 0.5	Cp:	pH 4.9 ± 0.1	BCp:	pH 5.2 ± 0.2

These are typical means for the pH-values of the different peats and they are well in accordance with the data reported by KIVINEN (1933). Only the pH in the Sp group is slightly higher and in the BCp group somewhat lower than the corresponding results reported by KIVINEN.

The correlation was calculated for the pH values and the cation contents of the peat groups and the following coefficients were obtained:

	Correlation coefficients between pH and			
	Ca p.p.m.	Mg p.p.m.	K p.p.m.	Na p.p.m.
Sp (32)	0.475**	0.469**	0.048	0.062
CSp (31)	0.407*	0.284	— 0.388*	— 0.067
SCp (59)	0.542***	0.172	— 0.374**	— 0.207
EuSCp (7)	0.927**	0.758*	— 0.374	0.472
Cp (46)	0.708***	0.458**	— 0.167	0.401*
BCp (33)	0.833***	0.275	— 0.210	0.172
All (208)	0.692***	0.470***	— 0.245**	0.199*

As could be expected the correlation between the pH-values and the content of calcium is fairly high in most of the peat types. The positive correlation between pH and magnesium content is less distinct for all the samples and for several of the peat groups no correlation between these quantities exists. The potassium content, on the other hand, tends to show a slight tendency to decrease with decreasing acidity. No correlation, worth of notice occurs between the acidity and the sodium content of these samples, except in the Cp group.

There is in these peat groups no significant correlation between the depth or the degree of humification and the pH-value. Therefore, it is unnecessary to calculate the partial correlation coefficients by eliminating the effect of the sampling depth and the degree of humification between the pH and the cation contents.

Extractable cations in the surface layers and the peat land quality

In the present material a large part of the samples originated from fairly deep layers. So far as the cultivation of peat soils is in question, generally only the surface layers are of importance. Therefore, also an examination of this part of the material is desirable.

The samples down to a depth of 3 dm contain, on the average the following quantities of calcium and magnesium:

	Ca p.p.m.	Mg p.p.m.
Sp (18)	3 510 ± 970	1 120 ± 280
CSp (12)	2 690 ± 730	1 590 ± 400
SCp (26)	2 930 ± 590	1 260 ± 202
EuSCp (2)	8 700 —	—
Cp (11)	4 380 ± 2 230	1 490 ± 620
BCp (11)	10 500 ± 4 370	2 680 ± 910

These mean values of the calcium content are equal to those calculated for the whole material, except in regard to the Cp group. These samples are markedly lower in calcium than the average of all the samples indicates. As to the magnesium content no significant difference appears to exist between the surface samples and the whole material.

The potassium content, on the other hand seems to be somewhat higher in the surface samples than in the deeper layers. The extractable sodium occurs in equal amounts in the surface peat and in the older deposits. The following mean values for potassium and sodium content in the surface samples demonstrate this.

	K p.p.m.	Na p.p.m.
Sp (18)	385 ± 150	120 ± 65
CSp (12)	445 ± 435	190 ± 90
SCp (26)	220 ± 60	115 ± 35
EuSCp (2)	1 145 —	1 120 —
Cp (11)	225 ± 155	185 ± 125
BCp (11)	190 ± 75	215 ± 55

The peat land quality estimated on the basis of the surface vegetation, mainly depends on the nutrient content and other conditions in the surface layers of peat. Therefore, when the contents of extractable cations and the degrees of land quality were studied, there was no cause to examine the whole material. The samples from layers not deeper than 3 dm were chosen to the object of this testing. The statistical treatment yielded the following results:

	Correlation coefficient between Bo and			
	Ca p.p.m.	Mg p.p.m.	K p.p.m.	Na p.p.m.
Sp (18)	0.034	— 0.218	0.170	0.064
CSp (12)	0.788**	0.341	— 0.147	0.374
SCp (26)	— 0.183	0.222	0.370	0.569**
EuSCp (2)	—	—	—	—
Cp (11)	0.225	0.342	0.240	0.383
BCp (11)	0.206	0.055	0.167	0.269
All (80)	0.551***	0.369**	— 0.025	0.149

It could be expected to find a fairly close connection between the calcium content and the land quality. This however, was not the case within the different peat types. For all the surface samples the correlation is significant, although not very high. The same holds true with the extractable magnesium for which the correlation is even lower. The scant supply of potassium in peat lands is not correlated with the land quality. The distribution of sodium in the surface samples does not correspond to the land quality.

Connection between the amounts of extractable cations

It seems possible that there exists some dependence between the quantities of these extractable cations in the peat samples. Indeed, a rather high correlation could be found for the contents of calcium and magnesium, as the following correlation coefficients indicate:

	Total correlation coefficients between the contents of			
	Ca and Mg	Ca and K	Mg and K	K and Na
Sp (32)	0.613***	0.142	— 0.075	0.238
CSp (31)	0.317	0.103	— 0.537***	0.329
SCp (59)	0.672***	— 0.013	0.039	0.059
EuSCp (7)	0.834*	— 0.585	0	0.295
Cp (46)	0.679***	0.109	0.201	0.247
BCp (33)	0.729***	— 0.105	— 0.491	0.646***
All (208)	0.782***	— 0.042	— 0.009	0.172

The data listed above show no connection between the contents of calcium and potassium on the one hand, or between the amounts of extractable magnesium and potassium, on the other hand. As to the potassium and sodium extracted by ammonium chloride, no significant correlation between them is to be found, except in the BCp group.

Discussion

This statistical study, the aim of which was to elucidate the nutrient conditions in regard to calcium, magnesium and potassium in different kinds of peat, gave results which emphasize the large variation of the nutrient content in every peat group. The individual data for one group are always overlapping the range of the other ones. Generally, even the means do not significantly differ from each other.

This large variation did not arise only from the fact that in the material analyzed the sampling depth varied from 1 to 60 dm. The extent of variation in the different groups of surface samples was as large as that for the whole material. No significant correlation was found to exist between the sampling depth and the content of the different cations, except in a few cases. This also shows that this variation must be attributed to some other reasons than the age of the deposit.

One factor which may be held liable for the variation in the contents of extractable cations in the different peat groups is the location of the sampling place in the peat land. It has been observed (Kivinen 1933) that particularly in large peat lands moistened by waters from outside the peat deposits on the edge of the area adsorb a large part of the cations in the running water and only water fairly poor in nutrients reaches the middle part of the peat bog. In the long run this, of course, brings about changes in the composition of the surface vegetation and further in the quality of peat. Meanwhile, this phenomenon may at least partly be held responsible for the large variation in the nutrient content within the same peat group.

Attention must also be paid to the fact that even each of these six peat groups may be composed of fairly different plant residues. The Sp group, for example, can be developed from residues of poor *Sphagnum fuscum* vegetation or from markedly richer residues of other *Sphagnum* species. Also the remains of *Carex* differ from each besides this, the nutrient content of plants depends on the nutrition conditions of the peat land and large variations even within the mineral composition of the same plant species may exist.

In any case, the results of this study emphasize that the determination of the kind of peat does not give any probable estimate of the nutrient content of the sample. An Sp sample may be richer in calcium, magnesium, and potassium than a Cp or a BCp sample.

Summary

An attempt was made to elucidate the content of plant-available calcium, potassium and magnesium in different kinds of virgin peat. The amounts of these cations extracted by 1 N ammonium chloride solution were supposed to give an estimate satisfactory for this purpose. Also the extractable sodium was determined.

The material consisted of 208 samples mainly collected from Northern Finland.

The variation in the content of extractable cations was high in all the peat groups. The individual values of one group were overlapping the range of other ones. The average calcium and magnesium contents of the Sp, CSp and SCp groups were somewhat lower than those of Cp, BCp and EuSCp groups. The same seems to be the case. with the content of extractable sodium whereas the moss peats tended to be slightly less poor in potassium than the peats of better quality.

A more or less significant correlation existed in all the peat groups between the calcium content and the pH-values. The correlation was markedly lower for pH and extractable magnesium. A weak tendency to negative correlation could be noticed between pH and extractable potassium.

The land quality and the calcium and magnesium content of all the surface samples were correlated with each other, although not very strongly. Within the different peat groups no correlation between these quantities could be found, except in one case. The scant supply of potassium in the surface samples did not show any connection with the land quality.

The reasons responsible to the large variation of the nutrient content within a certain peat group were discussed. The fact was emphasized that on the basis of the identification of the kind of peat nothing reliable is known of the nutrient content of the sample.

REFERENCES

(1) Cheng, K. L. & Bray, R. H. 1951. Determination of calcium and magnesium in soil and plant material. Soil Sci. 72: 449—458.

(2) Kaila, A. 1956. Determination of the degree of humification in peat samples. J. Sci. Agric. Soc. Finland 28: 18—35.

(3) —»— 1956 b. Phosphorus in virgin peat soils. Ibid. 28: 142—167

(4) —»— & Kivekäs, J. 1956. Extractable calcium, magnesium, potassium and sodium in different layers of peat soils. Ibid 28:

(5) Kivinen, E. 1933. Suokasvien ja niiden kasvualustan kasvinravintoainesuhteista. (Referat: Untersuchungen über den Gehalt an Pflanzennährstoffen in Moorpflanzen und in ihren Standorten.) Acta Agr. Fenn. 27. Helsinki.

SELOSTUS:

UUTTUVASTA KALSIUMISTA, MAGNESIUMISTA, KALIUMISTA JA NATRIUMISTA ERI TURVELAJEISSA

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Tutkimuksessa tarkastellaan turvelajeittain ammoniumkloridilla uuttuvien kalsiumin, magnesiumin, kaliumin ja natriumin määriä ja näiden riippuvuutta toisistaan.

Tutkimusaineistona oli 208 luonnontilaisilta, lähinnä pohjois-Suomen soilta otettua turvenäytettä. Ilmakuivista, jauhetuista näytteistä määritettiin kahden tunnin huiskutuksen aikana 1-n ammoniumkloridiliuokseen uuttuneiden em. kationien määrät; määritykset tapahtuivat Langen liekkifotometrilla ja versenaattititrausta käyttäen.

Tutkittujen näytteiden perusteella on vaikea saada selviä eroja eri turpeiden em. kationien pitoisuuksissa. Selvän rajan vetäminen rahka- ja sarturpeiden välille on vaikeata. Kalsiumia ja magnesiumia sisältävät S—t, CS—t ja myös SC—t keskimäärin vähemmän kuin muut turpeet. Myöskään ei selviä eroja eri turvelajien keskimääräisissä kaliumin ja natriuminpitoisuuksissa voida havaita. Kaliumin ja natriumin määrät ovat huomattavasti pienempiä kuin kalsiumin tai magnesiumin määrät.

Tarkasteltaessa erikseen pintanäytteiden (0—3 dm) kationipitoisuuksia havaitaan, että kalsiumin ja magnesiumin määrät ovat samaa suuruusluokkaa kuin muissakin näytteissä. Kaliumia sensijaan näyttäisi pintaturpeissa olevan keskimäärin runsaammin kuin syvemmältä otetuissa näytteissä.

Kalsiumin ja pH:n välillä voidaan eri turvelajeissa ja koko materiaalissa havaita melko selvä positiivinen korrelaatio. Pintanäytteissä vallitsee, koko materiali huomioonottaen, melko selvä positiivinen korrelaatio kalsiumin ja boniteetin sekä magnesiumin ja boniteetin välillä. Eri turvelajeissa ei näitä korrelaatioita sensijaan voida havaita.

Kalsiumin ja magnesiumin välillä voidaan havaita selvähkö positiivinen korrelaatio.
