THE VARIATION IN WATER CONTENT AND IN CONCENTRATIONS IN TRACE METALS IN PEAT IN DIFFERENT MIRE TYPES

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The mires in Ostrobothnia, Western Finland, can be classified into four types by trophic status: oligotrophic, oligo-mesotrophic, mesotrophic and meso-eutrophic mires. Geological investigations and analyses show that there are differences in the water content and in the concentrations of trace metals of peat between these mire types. The water content of peat is highest in oligotrophic mires, the average being 91.3%, and lowest in meso-eutrophic mires, where it is 86.4%. The water content of peat gradually decreases with an increase in the proportion of moss peat and in the degree of decomposition of peat from oligotrophic mires through oligo-mesotrophic and mesotrophic mires to meso-eutrophic mires. In all the mire types, Zn, Pb and Cd values are relatively high in peat, whereas Ni, Cr, Cu, Co and Mn show rather low concentrations in the uppermost peat layer. The concentrations of trace metals (Cr, Mn, Pb and Fe) in peat are highest in meso-eutrophic mires, but the concentrations of Co and Cu are highest in mesotrophic mires. The values of Zn are highest in oligotrophic mires and of Ni in oligo-mesotrophic mires. The concentrations of Cr, Cd, Mn, Fe and Pb gradually increase and those of Zn gradually decrease from oligotrophic mires through oligo-mesotrophic and mesotrophic mires to meso-eutrophic mires.

Key words: bogs, peat, water content, heavy metals, Oulu County, Finland.

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Introduction

Peat is a heterogeneous mixture of organic matter accumulated in a water-saturated environment. Previously, the differences in water content and in concentrations of trace metals at different peat depths were emphasized (Salmi 1955, Largin *et al.* 1972, Sillanpää 1972, Tanskanen 1976, Yliruokanen 1976, 1980, 1981, Pakarinen *et al.* 1977, 1978b, 1980, 1983, Glooschenko & Capobianco 1978, Peuravuori *et al.* 1988 and Virtanen 1990, 1991). However, little attention was paid to the variation in water content and in concentrations of trace metals in peat in different mire types. The purpose of this paper is to compare different mire types in terms of water content and the concentration of trace metals.

Study material

The study area, which lies in Ostrobothnia, Western Finland, comprises three regions in the municipalities of Ruukki, Vihanti and Oulainen

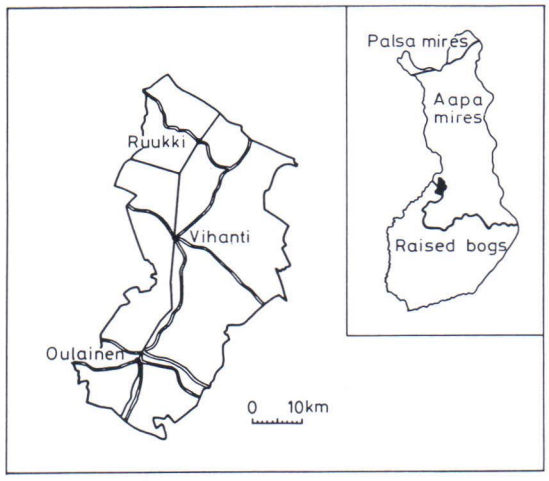


Fig. 1. The location of studied region.

(Fig. 1). Altogether 240 mires, with a total surface area of 50,000 hectares, have been investigated (Virtanen & Herranen 1984, 1986, 1987, 1988). The findings presented in this paper are based on the material investigated earlier. The degree of decomposition and the botanical characteristics of the peat and mire types were determined in the field (Lappalainen *et al.* 1984). The water content (DIN 19683) and the bulk density were measured with method by Korpijaakko (1981), and the concentrations of trace metals (Co, Cr, Cu, Mn, Ni, Pb, Zn, Cd and Fe)in peat were determined from peat ash by AAS (combustion temperature 450°C) and then calculated to dry peat in the laboratory.

Results

Mire and peat types

The mires of the study area can be classified by trophic status (Cajander 1913, Heikurainen & Pakarinen 1982, Ruuhijärvi 1983, Lappalainen *et al.* 1984) into the following types:

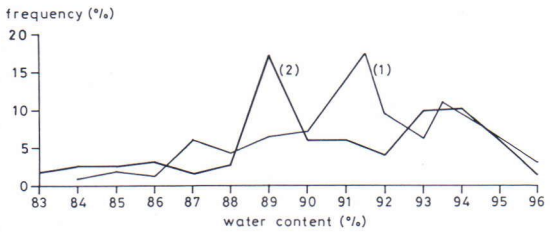
(1) oligotrophic mires;
(2) oligo-mesotrophic mires;
(3) mesotrophic mires;
(4) meso-eutrophic mires.

According to geological investigations (Virtanen and Herranen 1984, 1986, 1987, 1988) there are two main peat types in this region, i.e. Carex peat and Sphagnum peat. An average of 58% of the peat deposits are composed of Carex peat and 42% of Sphagnum peat. However the proportion of peat types differs from one mire type to another (Table 1).

Table 1. Statistical parameters of water content of peat in four types of mire.

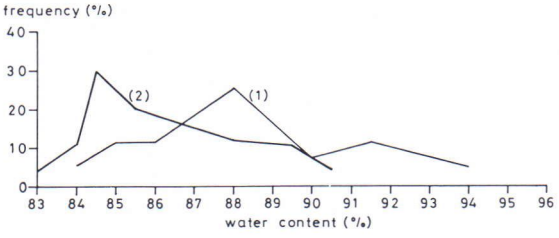
Mire types	Peat types S %	C %	mean(%)	Std.	Cv	Mmax(%)	Mmin(%)	N
oligotrophic mire	83	17	91.30	3.77	0.041	96.50	80.60	98
oligo-meso-trophic mire	76	24	89.40	4.18	0.047	95.50	80.50	46
mesotrophic mire	30	70	87.90	3.38	0.038	93.90	83.40	16
meso-eutro-phic mire	26	74	86.40	3.58	0.04	93.60	80.90	10

Std.: Standard deviation; Cv: Coefficient of variation;
Mmax: Maxiumum value; Mmin: Minimum value;
N: Number of sample.
S: Sphagnum
C: Carex



(1) oligotrophic mire (2) oligo-mesotrophic mire

Fig. 2. The frequency of water content of peat in oligotrophic mire and oligo-mesotrophic mire.



(1) mesotrophic mire (2) meso-eutrophic mire

Fig. 3. The frequency of water content of peat in mesotrophic mire and meso-eutrophic mire.

Water content

The water content in peat differs in the four mire types as shown in Table 1. The content is highest in oligotrophic mires, where it is 91.3% on average, and the coefficient of variation is only 0.041. It is lowest in meso-eutrophic mires, where it is 86.4% on average, and the coefficient of variation is 0.04. The mean values of the water content in peat in the four types of mire are in declining order:

oligotrophic mires > oligo-mesotrophic mires > mesotrophic mires > meso-eutrophic mires.

Figures 2 and 3 indicate that the water content in the peat of oligotrophic mires is usually in the range 89%-93% , the frequency in this range being 46.9%. In oligo-mesotrophic mires the content is from 88% to 91%, the frequency being 31.8%. In mesotrophic mires which make up 43.8% of the samples determined, the water content is in the range 86%—90%. The mode interval in meso-trophic mires, however, is 84%—88%, the freguency in this range being 73%.

The observed diversity depends principally on the types of dead plant remains and the degree of decomposition. It is also related to bulk density and microbiological activity. The leaforganism of moss peat is composed of transparent dead cells which can hold water. The water content is therefore highest in moss peat. Generally, the water content decreases as the degree of decomposition increases (Radforth & Brawner 1977). However, in highly decomposed peat, even though the amount of water retained at low suction decreases as decomposition increases, at higher suction more water is retained.

Remains of Sphagnum play a very important role in oligotrophic mires. The proportions of Sphagnum peat gradually decrease, from 83% to 26%, from oligotrophic mires through oligo-mesotrophic mires and mesotrophic mires to meso-eutrophic mires. The degree of humification of peat in oligo-trophic mires is higher than that in meso-eutrophic mires. Another reason why the water content of peat decreases with the change in mire type from oligotrophic through oligo-mesotrophic and mesotrophic mires to meso-eutrophic mires is that all the meso-eutrophic mires in the study area have been drained.

Concentrations of trace metals

The mean concentrations of the trace metals analysed in the different mire types are shown in Table 2. The different forms of expression of the analytical results are given in Table 3. Comparison of Table 2 with Table 3, reveals slight variations due to differences in the bulk density of peat in the four mire types.

The enrichment of elements in to the uppermost peat layer was evaluated by calculating the concentration ratios »uppermost peat/whole peat» (Table 4).

On the basis of Table 4, the following rankings were obtained:

Table 2. Mean concentrations of trace metals of peat in the four mire types.

mire types	Co (ppm)	Cr (ppm)	Cu (ppm)	Mn (ppm)	Ni (ppm)	Pb (ppm)	Zn (ppm)	Cd (ppm)	Fe (%)
oligotrophic	0.76	6.74	3.38	51.28	1.45	10.58	29.3	0.27	0.21
oligo-meso-trophic	1.22	19.24	4.37	59.75	2.78	14.24	21.17	0.29	0.54
mesotrophic	2.25	25.73	5.47	66.20	2.45	15.37	19.67	0.50	0.73
meso-eutro-phic	1.10	37.80	3.60	75.80	1.30	17.70	12.15	0.70	1.30

Table 3. The amount of trace metals as g/m³ dry peat in the different mire types.

mire types	Co	Cr	Cu	Mn	Ni	Pb	Zn	Cd	Fe
oligotrophic	0.08	0.71	0.37	5.56	0.16	1.15	3.18	0.03	227.83
oligo-meso-trophic	0.15	2.32	0.53	7.19	0.34	1.71	2.55	0.04	649.89
mesotrophic	0.30	3.44	0.73	8.85	0.33	2.06	2.63	0.07	976.16
meso-eutro-phic	0.13	4.35	0.42	8.73	0.15	2.04	1.40	0.08	1497.34

(1) oligotrophic mires
Zn, Pb > Cd > Cu, Mn, Co > Ni, Cr, Fe
(2) oligo-mesotrophic mires
Zn, Pb > Cd > Co, Cr, Ni Mn, Fe, Cu
(3) mesotrophic mires
Zn, Pb, Cd > Co, Fe, Cr, Cu > Mn, Ni
(4) meso-eutrophic mires
Pb, Zn, Cd > Cr, Co > Mn, Cu, Fe > Ni.

Significant differences can be seen in the levels of the nine trace metals in the four types of mire when compared with the average concentrations of trace metals in peat in the study region (Fig.4).

Discussion

Table 4 and Figure 4 show the characteristics and the trace metal contents of peat in different mire types.

(1) oligotrophic mires

Zn and Pb are enriched, but the contents of Cu, Mn, Co, Ni, Cr and Fe are consistently lower, in the uppermost peat. Only Cd shows a relatively small change in average value from the uppermost peat layer to the whole peat layer. The mean concentrations of all the elements except Zn, whose concentration is higher than in the other four types of mire, are low; those of Cr, Mn, Pb, Cd and Fe are especially low, being lower than in the other mire types, and, except for Zn and Pb, are lower than the mean concentrations of trace metals in the peat of the study region.

(2) oligo-mesotrophic mires

Apart from Zn and Pb, which appear to be enriched in the uppermost peat, all the elements except Cd show lower concentrations in the uppermost peat. Only Cd shows a relatively small change in average value between the uppermost peat layer and the whole peat layer. The mean content of Ni is the highest reconted in any of the mire types. With the exception of Zn, all other elemental concentrations, are higher than those in oligotrophic mires, and except for Zn, Co and Cu, are lower than those in mesotrophic and meso-eutrophic mires. Only Zn and Pb are higher

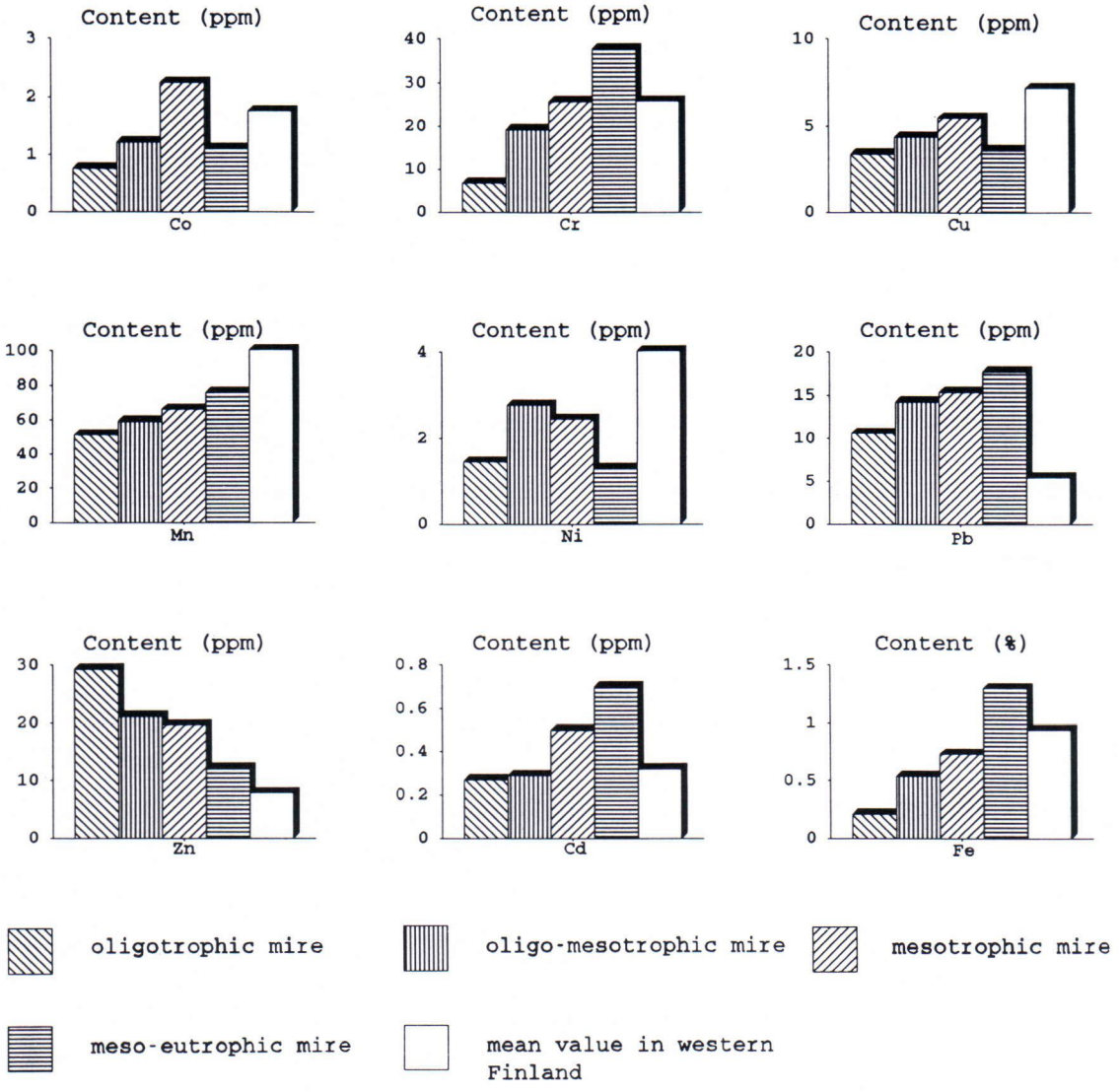


Fig. 4. The concentrations of trace metals of peat in different mire types.

Table 4. The ratios of trace metal concentrations in the uppermost peat layer to those in the whole peat layer.

mire types	Co	Cr	Cu	Mn	Ni	Pb	Zn	Cd	Fe
oligotrophic	0.52	0.38	0.60	0.58	0.43	2.20	2.90	1.13	0.33
oligo-meso-trophic	0.63	0.62	0.43	0.51	0.61	2.43	2.46	1.14	0.51
mesotrophic	1.01	0.89	0.89	0.55	0.55	2.24	2.50	1.72	0.92
meso-eutro-phic	0.80	0.90	0.77	0.78	0.3	2.42	2.03	1.27	0.73

than the mean concentrations of trace metals in the peat of the study area.

(3) mesotrophic mires

Zn, Pb and Cd are enriched in the uppermost peat, while Mn and Ni show lower concentrations. The Co, Fe, Cr and Cu of the uppermost peat show relatively small changes in the whole peat layer. The concentrations of Co and Cu are the highest observed in any of the mire types. The concentrations of Co, Cd, Zn and Pb are higher than the averages of all the studied material. The average values of Cr, Mn, Pb, Cd and Fe are higher than those in oligotrophic and oligo-mesotrophic mires and lower than those in meso-eutrophic mires.

(4) meso-eutrophic mires

While Pb, Zn and Cd appear to be markedly enriched in the uppermost peat, Ni exhibits lower concentrations. Co and Cr show a relatively small change in average value from the uppermost peat layer to the whole peat layer. The concentrations of Cr, Cd, Fe, Mn and Pb are the highest encountered in any of the mire types. The mean values of Cr, Pb, Zn, Cd and Fe are higher than those of peat in the study area. Only Ni and Zn show lower concentrations than in any of other mire types.

These results show some similaritiers with previous data on trace metal concentrations in different peat types. The concentrations of Zn and Pb in peat are clearly highest in the uppermost layer whether in different peat types or in different mire types (Salmi 1956, 1959, 1967, Tanskanen 1976, Pakarinen et al. 1977, 1980, Peuravuori & Pihlaja 1988, Shotyk 1988, Äikäs & Leino 1990, Sillanpää 1972, Elomaa 1981, Yliruokanen 1976, 1980, Virtanen 1991). On the other hand, the contents of Ni, Cr, Cu, Co and Mn in peat are quite low in the uppermost layer of Finnish mires (Salmi 1956, Tanskanen 1976, Sillanpää 1972, Yliruokanen 1976, 1981, Peuravuori & Pihlaja 1988). The content of Fe is highest in meso-eutrophic mires, and lowest in oligotrophic mires (Puustjärvi 1952, Tolonen 1974, Salmi 1955, Sillanpää 1972, 1975).

Conclusions

The following conclusions can be drawn from the variation in water content and in concentrations of trace metals in peat in different mire types:

1. The water content of peat decreases gradually from oligotrophic mires through oligo-mesotrophic and mesotrophic mires to meso-eutrophic mires, from 91.3% to 86.4%, on average. In oligotrophic and oligo-mesotrophic mires, the common ranges of the water content of peat are 89%—93% and 88%—91% respectively, and the respective freguencies are 46.9% and 31.8%. In mesotrophic and meso-eutrophic mires, however, the common ranges are 86%—90% and 84%—88% respectively, and the frequencies 43.8% and 73%, respectively.

This difference mainly depends on the type and humification degree of peat in different mires.

2. The average concentrations of the trace metals studied in peat differ in the four mire types. The concentrations of Cr, Mn, Pb, Cd and Fe the highest, but those of Ni and Zn are lowest, in meso-eutrophic mires. The concentrations of Zn and Ni are highest in oligotrophic and oligomesotrophic mires whereas the mean values of Cr, Mn, Pb, Cd and Fe are lowest in oligotrophic mires. Although the concentrations of trace metals in peat differ in the four types of mire, they do show some similarities. Zn, Pb and Cd have relatively high concentrations, whereas Ni, Cr, Cu, Co and Mn exhibit relatively low concentrations in the uppermost peat layer in all the mire types. More over the concentrations of Cr, Cd, Mn, Fe and Pb gradually increase from oligotrophic mires through oligo-mesotrophic and mesotrophic mires to meso-eutrophic mires while the content of Zn gradually decreases.

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