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ACCUMULATION OF MAJOR AND TRACE ELEMENTS IN FENS (LATVIA)

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SUMMARY

Major and trace elements in fen peat are very important indicators of past and current environmental conditions, as they indicate natural and anthropogenic pollution sources, for example, changes in atmospheric contaminant fluxes or climate change. In this study, the accumulation patterns of various major and trace elements were analyzed and their possible sources were evaluated. This paper reports on the accumulation patterns of major and trace elements in fen peat from four mires in Latvia and links this accumulation to the botanical composition and other characteristics of peat.

KEYWORDS: accumulation, chemical elements, fens, peat, pollution

INTRODUCTION

There are a few publications about fen peat composition and properties; hence it is important to conduct studies on fen peat to find out and to expand the application possibilities of this type of peat.

Fen peat is formed from decomposed plant remains. These plants have developed mostly by feeding from mineral-rich groundwater. In general, fen peat is built up from sedges, reeds, grasses, shrubs or wood under waterlogged conditions (Clymo, 1983; Foster and Fritz, 1987). The developed surface area and large number of acidic functional groups common to peat determine the ability to bind trace elements included in the remains of living organic matter, either as sedimentary, deposited, particulate matter, or as sorbed or complexed metal ions (Brown *et al*., 2000). The dominant sources of major and trace elements in the peat mass can be attributed to atmospheric precipitations, to metals present in the peat-forming plants as well as to supply from groundwater and surface runoff. It is important to determine links among these sources. The ability of peat to accumulate trace metals depends on the ability of metal ions to bind with the common functionalities in the structure of peat, and, as a consequence of this, the ability of metals can be arranged in the sequence Hg>Cu>Pb>Ni>Zn>Co>Cd>Mn (Rinquist and Ohorn, 2002).

As it has been demonstrated in numerous studies carried out over the last decades, significant increases in accumulation of trace metals in peat have been observed. It has been stated that peat can serve as a good indicator of recent as well as historical changes. At the same time, the metal accumulations in peat are highly regional. Therefore, it is important to analyze trace elements regionally with regard to their distance from the pollution sources. It is important to understand how changes in characteristics of fen peat depend on element accumulation, for instance, in comparison with raised bog peat (Silamikele *et al*., 2010), as far as fen peat contains much higher concentrations of major elements, of which notable are the

concentrations of Ca^{2+} and Mg^{2+}. Their amounts can reach even hundreds of grams per kilogram of air-dried fen peat weight.

The main goal of this study was to explore and analyze the distribution and accumulation patterns of major and trace elements in fen peat under differing environmental conditions in Latvia.

MATERIALS AND METHODS

Site Location

The areas chosen for this research were four fens in the territory of Latvia. It was *Elku* Mire, *Vīķu* Mire, *Svētupes* Mire and *Salas* Mire. From each of these fens, according to their configuration, several full peat profiles were obtained. After sampling, the peat profiles were cut into slices of 5 cm and stored at -20°C until analysed.

In general, these mires characterize environmental conditions in Latvian fens; so, this situation was assumed as one of the main criteria for selection of study area.

METHODS

Besides the determination of major and trace elements by atomic absorption spectrometry using flame atomization (Welz and Sperling, 2007), the botanical composition and decomposition degrees of the peat samples were also determined, as well as loss on ignition analysis (Heiri *et al*., 2001) and radiocarbon dating were performed. Data analysis was conducted using SPSS 12.0 for Windows. The accumulation pattern of studied elements was visualized using Tilia 1.7.16 for Windows.

RESULTS

In this study we found that concentrations of some of major elements significantly changes depending on their location in peat profile. In general, there were concentrations of thirteen chemical elements determined, such as Ca, Mg, Fe, Mn, Zn, Cu, Na, K, Cd, Co, Cr, Ni and Pb; however in several peat profiles, for instance, in the *Svētupes* peat profile, concentrations of some trace elements (for example, Cd, Co etc.) were below the detection limit, so they were not determined.

In this study, chemical elements, the concentrations of which exceeds the percentage of the total air-dried peat mass (>0.01 g/kg), have been designated as major elements, and chemical elements, the concentrations of which did not exceed 0.1 percent of total air-dried peat sample mass (<0.01 g/kg), have been designated as trace elements.

The absolute values of element concentration in fen peat and their intervals are quite similar to concentrations of major and trace elements in peat from other mires of Latvia (Silamikele *et al*., 2010). The most common major elements in fen peat from the study area were calcium, magnesium and iron; however, there were differences in their sequences observed. Ca^{2+} and Mg^{2+} are the main plant nutrients; they are among the most important elements involved in the development of mire and its vegetation.

Calcium is the most common major element in the fen peat of *Elku* Mire (Fig. 1). The concentration varies between 16.85 and 40.83 g/kg (29.10 g/kg in average). The highest Ca^{2+} concentrations were observed in the middle section of the peat profile within the depth range from 0.75 to 1.50 m, and these concentrations are typical for wood-reed fen peat and reed fen peat layers. There were lower Ca^{2+} concentrations detected in the top (wood fen peat) and bottom (reed fen peat) parts of *Elku* peat profile, which might be affected or influenced by groundwater flow and leaching processes.

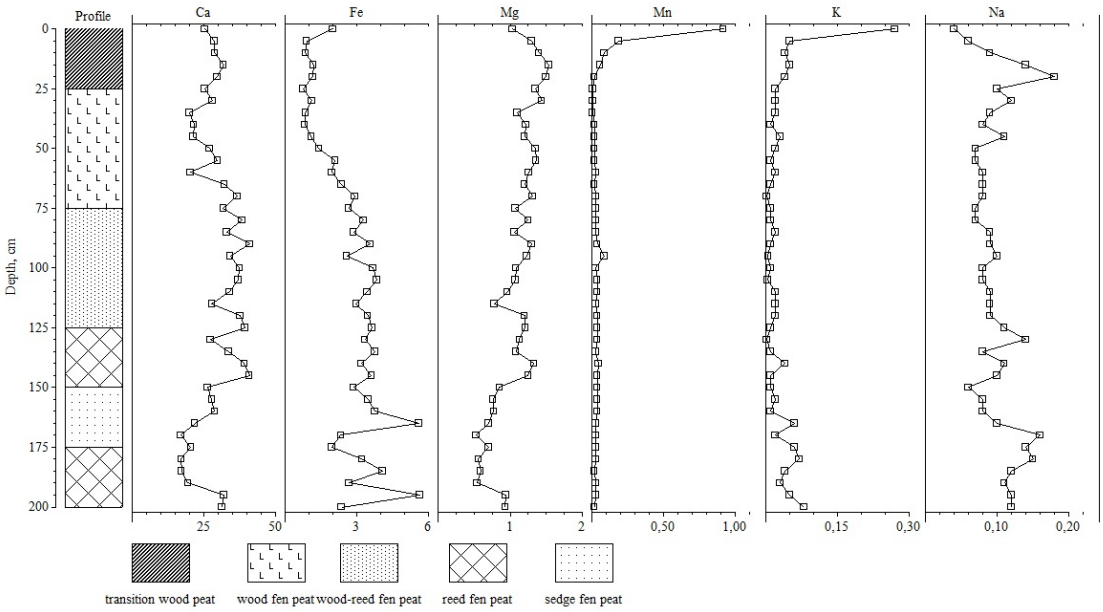

Fig. 1. The distribution pattern of most common elements (g/kg) in *Elku* Mire peat.

Ca^{2+} is most common also in the remaining mires, though there are changes in sequence of other major elements. For instance, in fen peat of *Vīķu* Mire, the second common major element is magnesium (Fig. 2), with the minimum amount of 0.67 g/kg, average of 1.15 g/kg and highest concentration of 1.84 g/kg; however, in the peat of *Elku* Mire, the second common element is iron (Fe^{3+}), with the average concentration of 2.65 g/kg, which exceeds the Mg^{2+} average concentration in this mire more than twice.

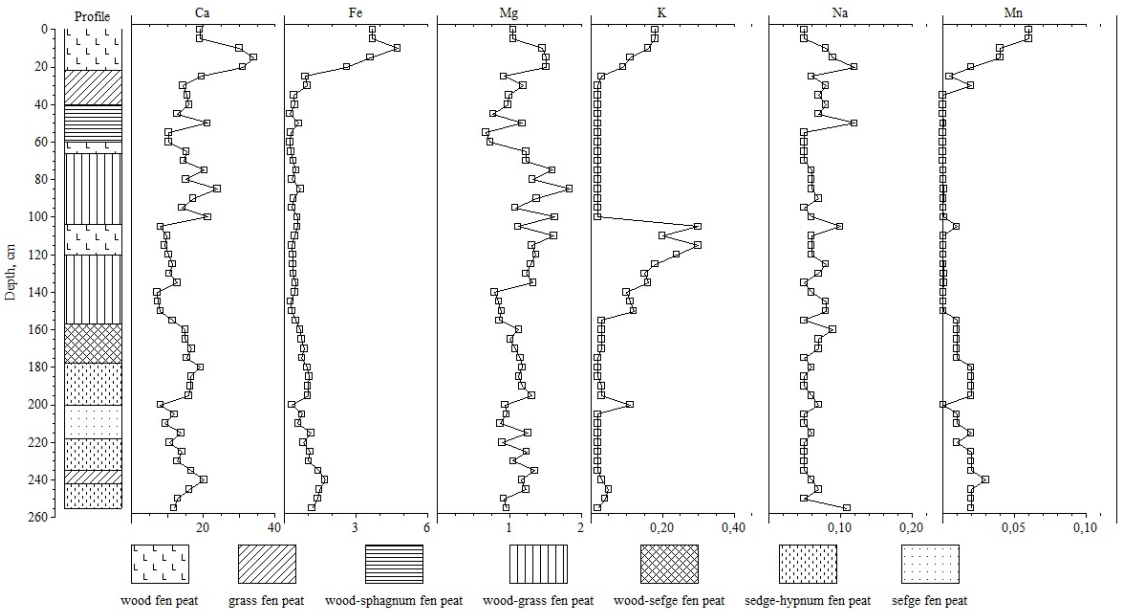

Fig. 2. The distribution pattern of most common elements (g/kg) in *Vīķu* Mire peat.

The situation with these three major elements in *Svētupes* Mire (Fig. 3) is different; i.e. there are significantly different concentrations of them, for instance, the concentration of Ca^{2+} varies between 4.56 and 171.26 g/kg (37.44 g/kg in average), and large amounts of calcium were observed in the sedge fen peat layer from 1.50 to 1.70 m – it was also corresponding with high pH levels (>7). In addition, the highest concentration of magnesium in *Svētupes* Mire is significantly higher than in peat of other mires (3.10 g/kg in average), as well as iron concentration (4.78 g/kg in average).

It is important to note that fen peat at *Salas* Mire contains the lowest calcium concentration in comparison with other observed peat profiles. The highest concentration there reaches only 22 grams per kilogram.

There were also differences in the trace element distribution observed, even in the peat profiles of relatively close located mires (*Elku* Mire and *Vīķu* Mire). Fortunately, there was no high contamination of heavy metals observed, for example, the highest lead concentration in *Elku* peat reaches only 3.5 mg/kg, and cadmium – only 0.59 mg/kg. Such trace elements as Pb and Co in the fen peat profile from *Svētupes* Mire were also very low almost in all cases (5 cm depth intervals); these elements were below the detection limit level (below 0.12 mg/kg for Co and below 0.50 mg/kg for Pb).

The fossil fresh-water mollusc remains, such as *Bithynia tentaculata*, *Valvata macrostoma* and others, which were detected in the fen peat of *Elku* Mire and *Svētupes* Mire, represent calcium-rich still water conditions in the past, significantly affecting further fen development. These remains can as well be linked to the carbonate content of peat – they can be part of it.

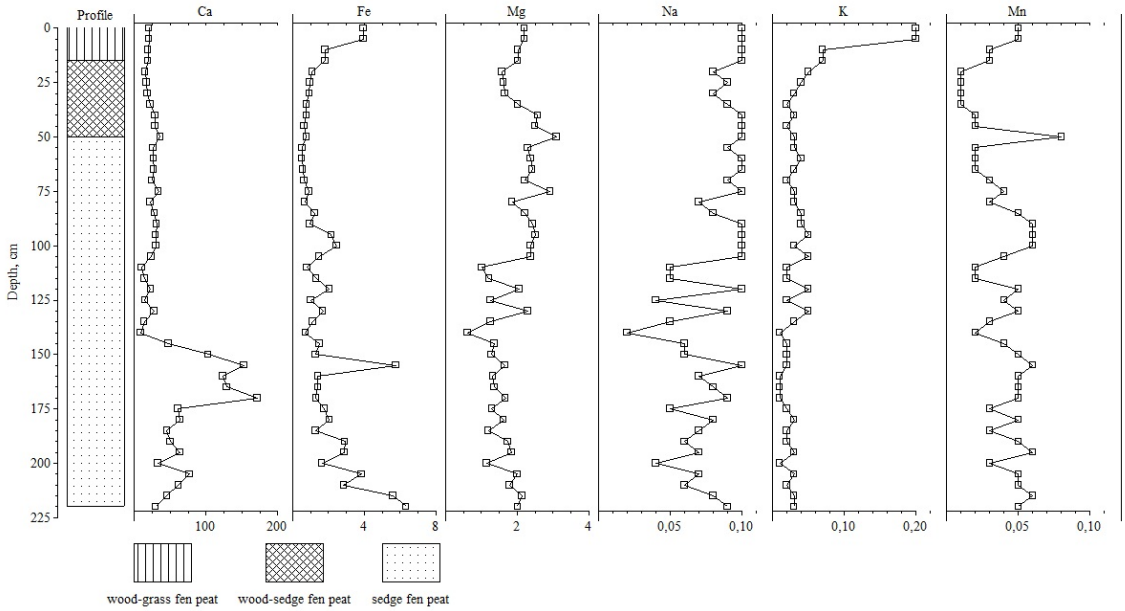

Fig. 3. The distribution pattern of most common elements (g/kg) in *Svētupes* Mire peat.

DISCUSSION AND CONCLUSIONS

Calcium is the most common metal in the studied fen peat. Its concentrations and distribution are linked to carbonate content – Ca and carbonate distribution curves are almost always similar. The high distribution of iron, in turn, can be linked to the mineral content in peat, and it may be caused by impacts from adjacent areas. It can be concluded that the main precondition for distribution of Ca might be the weathering of carbonate sediments in the depressions of mires and regular replacement of the peat layers of varied botanical composition. The calcium-rich still water conditions supported the development of rich vegetation and contributed towards overgrowing process and development of fen. The analysis of botanical composition shows that increased Ca concentrations in peat can also be attributed to reed remains, while the distribution of Mg can be negatively associated with sedge remains. The sequences of changes in bog vegetation, such as *Sphagnum centrale*, *Equisetum* or *Eriophorum latifolium* remains in fens indicate the changes in nutrient availability for plants, thus also changes in the accumulation rates of chemical elements or their depletion.

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