

Organic matter accumulation related to the annual temperature and precipitation in ombrotrophic peat bogs in Finland

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Introduction

Due to massive organic matter accumulation (in which approximately 50 % is C), peatlands form an enormous reservoir of terrestrial carbon. Factors controlling accumulation of the organic matter in peat include climate, vegetation, nutrients and decomposition rate. The highest long-term rates of peat accumulation have been measured from raised ombrotrophic bogs in which *Sphagnum* species are dominant. In general, new peat accumulates because of the slow rate of decomposition rather than a high rate of net primary production. However, in some years net losses can occur, which are considered to be related to fluctuations of the water table.

Age-dated peat cores from ombrotrophic peat bogs have been used successfully to establish records of atmospheric pollution, but they could also be used to estimate carbon accumulation rates in peatlands. Our objective was to study relationship between peat accumulation and annual temperature sum and precipitation in three different ombrotrophic peat bogs in Finland, two being polluted with heavy metals and one being pristine.

Material and methods

The study relates to three *Sphagnum* dominated ombrotrophic peat bogs in Finland (Fig 1). The Harjavalta site is located 6 km northeast of a large Cu-Ni smelter, the Outokumpu site 8 km southeast from a Cu-Ni mine, (operated until the end of the 1980s), and the Hietajärvi site is a background site with no point sources of air pollution nearby.

At each sampling site one peat core (15x15x100cm) was taken in September 2001 using a Titanium Wardenaar corer (Figs 2, 3), and the sample was cut into 1 cm slices. Organic matter (OM) accumulation was calculated from the sample volume and bulk density values for each 1-cm-layer. Age dating of peat was done using ²¹⁰Pb dating method and applying the constant rate of supply (CRS) interpretation. The local annual temperature sum and precipitation (Fig 4) were modeled back to the year 1880 using the method of Ojansuu and Henttonen (1983). Regression analyse was used to examine relationship between precipitation, temperature sums and organic matter accumulation.

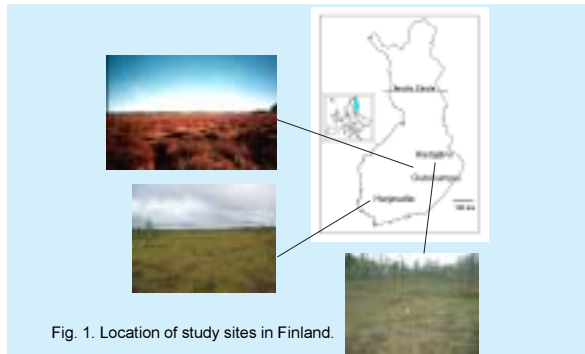


Fig. 1. Location of study sites in Finland.



Fig. 2. Peat core sampling with Wardenaar corer at Hietajärvi.

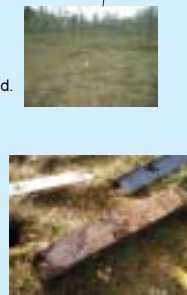


Fig. 3. Peat core at Hietajärvi site.

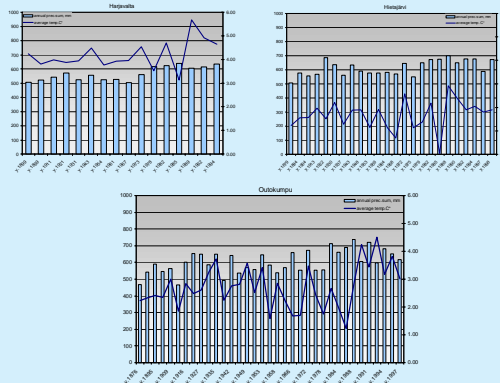


Fig. 4. Mean annual temperature and annual precipitation sum at the Harjavalta, Outokumpu and Hietajärvi sites using the method by Ojansuu and Henttonen (1983).

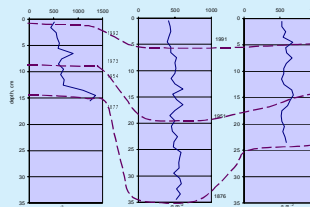


Fig. 5. Organic matter accumulation rate at Harjavalta, Outokumpu and Hietajärvi sites. Age dating of peat was done using ²¹⁰Pb dating method. Red line indicates peat of same age.

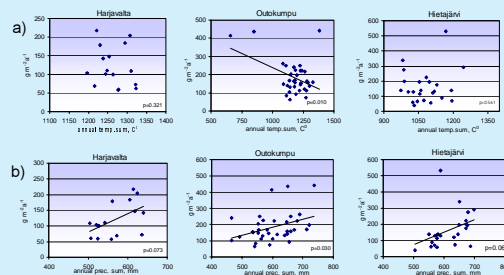


Fig. 6. Relationship of dry organic matter accumulation over the past 125 years to a) annual temperature sum and b) precipitation sum at Harjavalta, Outokumpu and Hietajärvi sites.

Results and discussion

Based on ²¹⁰Pb age-dating, upper 16 cm of peat at Harjavalta, 35 cm at Outokumpu and 25 cm at Hietajärvi represents the remains of 125 years accumulation (Fig. 5). Over that period the OM accumulation rate averaged 96 g m⁻² a⁻¹ at Harjavalta, 140 g m⁻² a⁻¹ at Outokumpu and 115 g m⁻² a⁻¹ at Hietajärvi (Fig 5). Peat thickness increased on average by 1.3 mm a⁻¹ at Harjavalta, 2.8 mm a⁻¹ at Outokumpu and 2.0 mm a⁻¹ at Hietajärvi during same period. At Harjavalta peat growth was only 1 mm or less before year 1953, which was noticeable less than at the other sites. This suggests that some local environmental factor had disturbed development of peat at Harjavalta in surface layers, e.g. local drought periods or Cu-Ni smelter derived pollutants might have caused reduced peat growth.

Results from regression analyses (Fig 6) indicated that the annual precipitation correlated positively with the OM accumulation rate at Outokumpu (p=0.030), while the annual temperature sum correlated negatively (p=0.010). A negative correlation with temperature was expected because the cool and moist conditions slow the decomposition process and hence promotes peat accumulation, whereas in warmer conditions decomposition is faster and due this the peat accumulation is less. A positive correlation between OM accumulation and precipitation reflects high water table levels and anaerobic conditions that reduce peat decomposition. Both at Hietajärvi (p=0.063) and at Harjavalta (p=0.073) precipitation sum correlated slightly with OM accumulation rate.

Conclusions

The Outokumpu site had the highest OM and peat accumulation rate over the studied period. Differences in OM accumulation rates during the last 125 years were related to temperature (Outokumpu site) and precipitation (Outokumpu, Hietajärvi and Harjavalta sites). Secondly the differences in OM accumulation rates between the sites were caused by the specific local condition. This was especially case at the Harjavalta site, where OM accumulation rate was considerable less than in the other sites.

References

Ojansuu, R. & Henttonen, H. (1983) Estimation of the local values of monthly mean temperature sum and precipitation sum from the measurements made by the Finnish Meteorological Office. *Silva Fenn.* 17(2):143-160. (in Finnish with English summary).