

Acetate accumulations in shallow and deep layers of peat bogs as a potential source of atmospheric CH₄

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A series of porewater profiles from two *Sphagnum* peat bogs have been measured in the years 1993/1994. The field area in the Jura Mountains (Switzerland) is characterized by an elevation of approximately 1000 m, a mean annual temperature of 5°C, and an annual rainfall of *c.* 1300 mm. At one of the bogs (EGr) 640 cm of peat accumulated since approximately 12'000 years BP. The upper part (*c.* 250 cm) of this bog represents ombrotrophic peat (*ombrotrophic* = rain-water-fed, i.e. not influenced by groundwater). The other bog (TGe) is characterized by lower peat accumulation (140 cm), with a thin ombrotrophic layer (*c.* 20 cm). More detailed information on the sites as well as on sampling and analytical techniques are given in Steinmann and Shotyk (1997) and references therein.

Acetate concentrations in the surface layers have been found to be highly variable in shallow (< 70 cm) peats at both sites, but also in deeper layers at EGr. At TGe high levels of acetate (maximum: 431 µM) were found in June 1993, which were much reduced by July (Fig. 1) and below the detection limit of *c.* 0.4

µM in November. In June 1994 acetate was well measurable, but not detected in October of the same year throughout the whole profile (down to 1.8m).

In 1993 at EGr (Fig. 2) acetate was detectable (max. 33 µM) in shallow peats in June but absent in November. In 1994 at EGr acetate in shallow peat was not detected in May but abundant in July (max. 288 µM) and again absent in October.

In contrast to the shallow peats, in deep layers at EGr a continuous accumulation of acetate was observed from June through October 1994

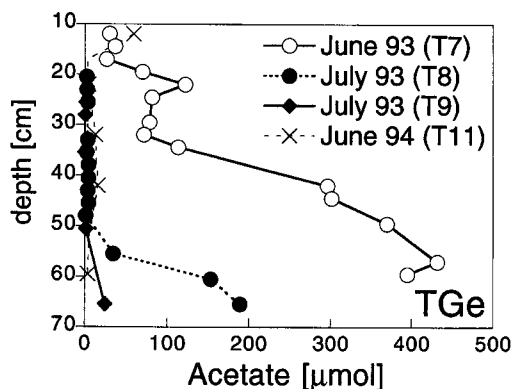


FIG. 1. Acetate concentrations measured in porewaters of peat bog TGe (ion chromatography: AS4A-SC column, borate gradient, injection volume 100 µl).

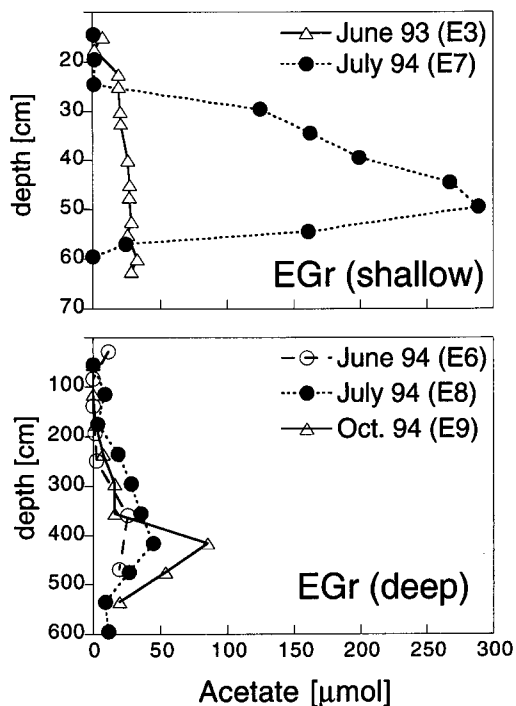


FIG. 2. Acetate concentration profiles measured in shallow layers (upper diagram) and in deep peats (lower diagram) at peat bog EGr.

(maximum concentrations increasing from 25 μM to 85 μM , Fig. 2).

In terms of total acetate pool sizes, at TGe the shallow (<70 cm) acetate pool of nearly 100 mmol m^{-2} in June 1993 diminished to approximately 2 mmol m^{-2} by July 1993.

In addition to the acetate accumulation in shallow peats a second pool of "deep" acetate is found at EGr. In July 1994 the pools of shallow (top 70 cm) and deep (200-500 cm) acetate pools stored approximately 60 and 90 mmol m^{-2} , respectively. While the peak concentrations at a depth of c. 415 cm doubled from July to October 1994 the total pool of acetate (200–500 cm) increased by some 10%.

Shannon and White (1996) in their study of acetate accumulation in shallow peat layers of two bogs in southern Michigan found maximum acetate concentrations in spring. The apparent later onset of acetate accumulation at TGe and EGr may have to do with optimum peat temperature for microbial acetate accumulation which might be reached later in the Jura sites than in the Michigan bogs (and later in deep layer compared to shallow layers). Shannon and White found that high sulphate concentrations delayed the onset of acetate accumulation, due to the competition between autotrophic acetogens and sulphate reducing bacteria. However, in the Jura bogs the sulphate concentrations were very low throughout the year (< 2 μM , often < 0.5 μM).

The fermentation of the available acetate is an important source of atmospheric methane (e.g. Shannon and White, and refs. therein). Measurements of stable carbon isotopes of dissolved CO_2 (DIC) from the porewater profile E9 are shown in Fig. 3. The measured $\delta^{13}\text{C}$ values may be reproduced by a simple model which assumes that dissolved CO_2 is produced by acetate fermentation. Model assumptions include further $\delta^{13}\text{C}$ values of

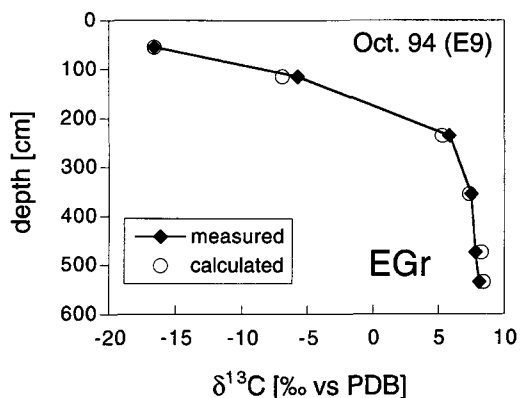


FIG. 3. Stable carbon isotope $\delta^{13}\text{C}$ values measured on dissolved inorganic CO_2 (DIC) from a porewater profile of peat bog EGr.

acetate and the produced methane to be -25‰ and -64‰ , respectively. The extent of reaction was chosen such that the calculated CO_2 concentrations matched the measured DIC. (The introduction of CO_2 via diffusion from local groundwater is relatively unimportant as can be shown by the low Ca concentrations in the porewaters.) Accordingly, it seems plausible that methanogenesis from acetate is a major sink of acetate (in both shallow and deeper peat layers) as well as a major source of DIC and possibly of atmospheric CH_4 .

References

- Steinmann P. and Shotyk W. (1997) *Geochim. Cosmochim. Acta*, **61**, 1143–63.
- Shannon, R.D. and White, J.R. (1996) *Limnol. Oceanogr.*, **41**, 435–43.