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Depth rather than microrelief controls microbial biomass and kinetics of C-, N-, P- and S-cycle enzymes in peatland

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A R T I C L E I N F O

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A B S T R A C T

The formation of microrelief forms in peatlands - elevated and dry hummocks, depressed wet hollows and intermediate lawns - is controlled by the interaction of water table, nutrient availability and dominant plant communities. This affects the composition and activity of various functional groups of microorganisms. With depth, the change in peat quality from less to more highly processed organic material additionally regulates microbial activity. We hypothesized that microbial biomass and enzyme activities are driven by aeration and by peat quality and therefore (i) they increase from hollows (water saturated/anaerobic) through lawns (intermediate) to hummocks (aerobic) in the top peat and ii) they decrease with depth due to increasing distance from fresh plant-derived inputs and lower oxygen availability. These hypotheses were tested for enzymes catalysing the decomposition of C-, N-, P- and S-containing organic compounds in peat of the three microform types at three depths (15, 50 and 200 cm). Microbial biomass and peat chemical characteristics were compared with enzyme kinetic parameters, i.e. maximal potential activity (V_{max}) and the Michaelis constant (K_m).

Microbial biomass carbon (MBC) and V_{max} of β-glucosidase and *N*-acetyl glucosaminidase increased by 30–70% from hummocks and lawns to hollows in the top 15 cm, contradicting the hypothesis. Similarly, K_m and the catalytic efficiency of enzymes ($K_a = V_{max}/K_m$) were best related to MBC distribution and not to the aeration gradient. With depth, V_{max} of β-glucosidase, xylosidase and leucine aminopeptidase followed the hypothesized pattern in hollows. In contrast, MBC was 1.3–4 times higher at 50 cm, followed by successively lower contents at 15 and 200 cm in all microforms. The same depth pattern characterized the V_{max} distribution of 6 out of 8 enzymes. Phosphatase activity decreased from drier hummock to wetter hollows and the higher activity throughout the peat profile suggested a high microbial demand for P. Enzyme activities and catalytic efficiency in peat were closely linked to the distribution of microbial biomass with depth, which in turn was best explained by P content. From the ecological perspective, these results clearly show that peat decomposition will be accelerated when microbial activity is stimulated e.g. by increased P availability.

1. Introduction

Peatlands are an important source of greenhouse gases (GHG) and play a key role in the global carbon (C) budget (Lai, 2009). Boreal peatlands (> 45°N) cover only 3% of the terrestrial surface but contribute a significant portion of CH_4 (46 Tg CH_4-C yr^{-1}) to the atmosphere and are a steady sink for CO_2 (Limpens et al., 2008; Nilsson et al., 2008). Due to low annual mean temperatures and dominant anoxic belowground conditions, the rate of litter decomposition in peatlands is slow, leading to a net C accumulation (Moore and Basiliko, 2006). Nonetheless, C pools and storages here may become vulnerable due to continuous temperature increase and change of precipitation (IPCC, 2013) as well as eutrophication. According to IPCC (2013), the annual CO_2 emissions from anthropogenic greenhouse gas sources including changes in forestry and other land use systems are predicted to increase by 27 Gt in the upcoming decade. This makes it critically important to understand mechanisms regulating the C balance in peatlands.

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