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Accumulation of organic carbon, its turnover and CO_2 emissions from soils under three vegetation types: results of a lysimeter study

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Prediction the future CO_2 emissions imply understanding of carbon (C) cycle and C turnover in soils under the different vegetation. One of the problems limiting the explanatory power of many studies is the fact that the soil age is not known exactly and the most studies accept that the soils are more or less under steady state. However, the intensity of soil processes depends on soil age and equilibrium between present vegetation and soils and so, if we compare processes under different vegetation we have to select the soils with similar formation period. The second important factor affecting explanatory power of our experiments is the soil parent material that should be identical by comparison of CO_2 fluxes from soils under different vegetation.

To meet these challenges we studied C cycle in a unique long-term lysimeter experiment started 43 years ago on 3 x 3 m^2 plots with 3 vegetation types: coniferous forest (*Picea abies*), broadleaf forest (*Acer platanoides* and *Quercus robur*) and grassland (totally 10 grasses and herbs species with dominance of *Lolium perenne*). The soil parent material for lysimeter filling was loam originated from the coverloam of the last Waldai glaciation; the loam was free of stones, carbonates and organic C. So, during 43 years the soils were developed on identical parent material under three vegetation types. Soil samples were collected in 2010 from 0-5; 5-10; 10-15 and 15-20 cm depths under three vegetation types and roots were completely removed before analyses by sieving. All soils were analyzed for total organic C (SOC), CO_2 efflux under controlled conditions, and microbial biomass C (C_{mic}) in the bulk soil and in three aggregate classes (> 2000 μm, 250-2000 μm and < 250 μm).

CO_2 production rates from soil under grassland were for 73% in 0-10 and 45% 10-20 cm lower than under broad leaf forest. CO_2 production rates from soil under coniferous forest were for 48% and 52% (in 0-10 and 10-20 cm, respectively) lower than under broad leaf forest. The respiratory quotient (qCO_2, the ratio between CO_2 production rates and C_{mic}) in the soil under grassland was 0.74 μg C mg^{-1} C_{mic} h^{-1} in 0-5 cm and increased to 1.58 μg mg^{-1} C_{mic} h^{-1} in 15-20 cm. qCO_2 under the broad leaf forest ranged from 1.34 in upper layer to 3.41 μg mg^{-1} C_{mic} h^{-1} in 15-20 cm layer. The ratio of C_{mic} to SOC was highest in soils under grassland: 1.9% and lowest under the broad leaf forest 0.9% in 0-5 cm layer. These parameters for soil under coniferous forest were between that under grassland and broad leaf forest. The soil under the broad leaf forest had the highest SOC (64.9 g kg^{-1} and 24 g kg^{-1} in the 0–5 cm and 5-10 cm layers, respectively). In 10-15 cm and 15-20 cm layers the SOC content ranged from 2 to 7 g kg^{-1}. The lowest SOC was under the grassland – 5-10 g kg^{-1} (for 0-5 cm). The highest rates of carbon accumulation comprise the 1.5 g $kg^{-1}year^{-1}$.

The SOC in separated aggregate fractions was highest in small macroaggregates (250-2000 μm) and ranged from 21 to 63.5 g kg^{-1} in the 0–5 cm layer up to 4.0–7.1 g kg^{-1} in the 5–10 cm layer under the broad leaf and coniferous forest, respectively. In contrast, the SOC content under grassland was highest in large macroaggregates amounting for 3.1 to 5.8 g kg^{-1} in different layers. CO_2 production from and microbial biomass in individual aggregate fractions showed further differences in C stabilization under the investigated vegetation types and allowed to estimate turnover rates of microbial biomass and of SOC.

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