ELSEVIER

Soil Biology & Biochemistry 37 (2005) 2163–2166

Soil Biology & Biochemistry

www.elsevier.com/locate/soilbio

Short communication

Humus accumulation and microbial activities in calcari-epigleyic fluvisols under grassland and forest diked in for 30 years

Oliver Dilly*, Anja Gnaß, Eva-Maria Pfeiffer

Institut für Bodenkunde, Universität Hamburg, Allende-Platz 2, 20146 Hamburg, Germany

Received 6 December 2004; received in revised form 2 March 2005; accepted 24 March 2005

Abstract

The accumulation and transformation of organic matter during soil development is rarely investigated although such processes are relevant when discussing about carbon sequestration in soil. Here, we investigated soils under grassland and forest close to the North Sea that began its genesis under terrestrial conditions 30 years ago after dikes were closed. Organic C contents of up to 99 mg g^{-1} soil were found until 6 cm soil depth. The humus consisted mainly of the fraction lighter than 1.6 g cm^{-3} which refers to poorly degraded organic carbon. High microbial respiratory activity was determined with values between 1.57 and 1.17 μg CO_2–C g^{-1} soil h^{-1} at 22 °C and 40 to 70% water-holding capacity for the grassland and forest topsoils, respectively. The microbial C to organic C ratio showed values up to 20 mg C_{mic} g^{-1} C_{org}. Although up to 2.69 kg C m^{-2} were estimated to be sequestered during 30 years, the microbial indicators showed intensive colonisation and high transformation rates under both forest and grassland which were higher than those determined in agricultural and forest topsoils in Northern Germany.

Keywords: Carbon sequestration; Organic carbon; Microbial biomass; Microbial respiration; Reclamation; Soil development

Carbon sequestration in soil became great attention since soil represents a great organic carbon pool of 1500–2000 Gt in comparison to 450–650 Gt stored in the vegetation and 730 Gt in the atmosphere (German Advisor Council on Global Change, 2003). Beside carbon sequestered by the vegetation and stored in Histosols, agricultural management practices and particularly the tillage system may contribute to global soil organic C dynamics (Lal et al., 2004).

A key component when analysing carbon sequestration is soil respiration under field conditions. The magnitude of soil carbon liberation by respiratory processes is assumed to be 10-fold higher than human fossil fuel combustion and 2.5-fold higher than litter deposition to soil (Andrews and Schlesinger, 2001). Small modification of climate conditions may switch soil balance from C source to C sink or vice versa.

Beside soil respiration estimated in the field, microbial basal respiration under laboratory conditions is considered as an indicator for soil quality referring to both current microbial physiology and C mineralization intensity (Dilly, 2005). In addition, substrate-induced respiration refers to microbial biomass content (Anderson and Domsch, 1978) and the combination of both characterise ecosystem development (Wardle and Ghani, 1995).

Based on C pools and microbiological indicators, the aim of this study was to quantify the content and composition of accumulated humus and also to evaluate the microbial activity in young soils close to the North Sea.

In 1973, the influence of the North Sea was eliminated at the 'Katinger Watt' by closing the dike and belongs to a natural reserve. The reclaimed site has a long-term mean annual temperature of 7.9 °C with an annual rainfall of approximately 800 mm. Grassland containing mainly *Festuca* at the sampling period was at one part, forest stands with *Populus*, *Alnus*, *Quercus*, *Fraxinus* and *Acer* ssp. were afforested at another part (Fig. 1). The forest on marshland soils represents an unusual land-use system.

Two guiding sites below grassland and forest were selected from which basic soil properties were determined (Grassland 54° 16,75′N; 8° 52,29′ E; *Quercus* forest 54° 16,40′N; 8° 52,21′E). During the 30 years, the grassland was lightly grazed by sheep during summer and autumn or cut in

* Corresponding author.
E-mail address: o.dilly@ifb.uni-hamburg.de (O. Dilly).

0038-0717/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.soilbio.2005.03.014

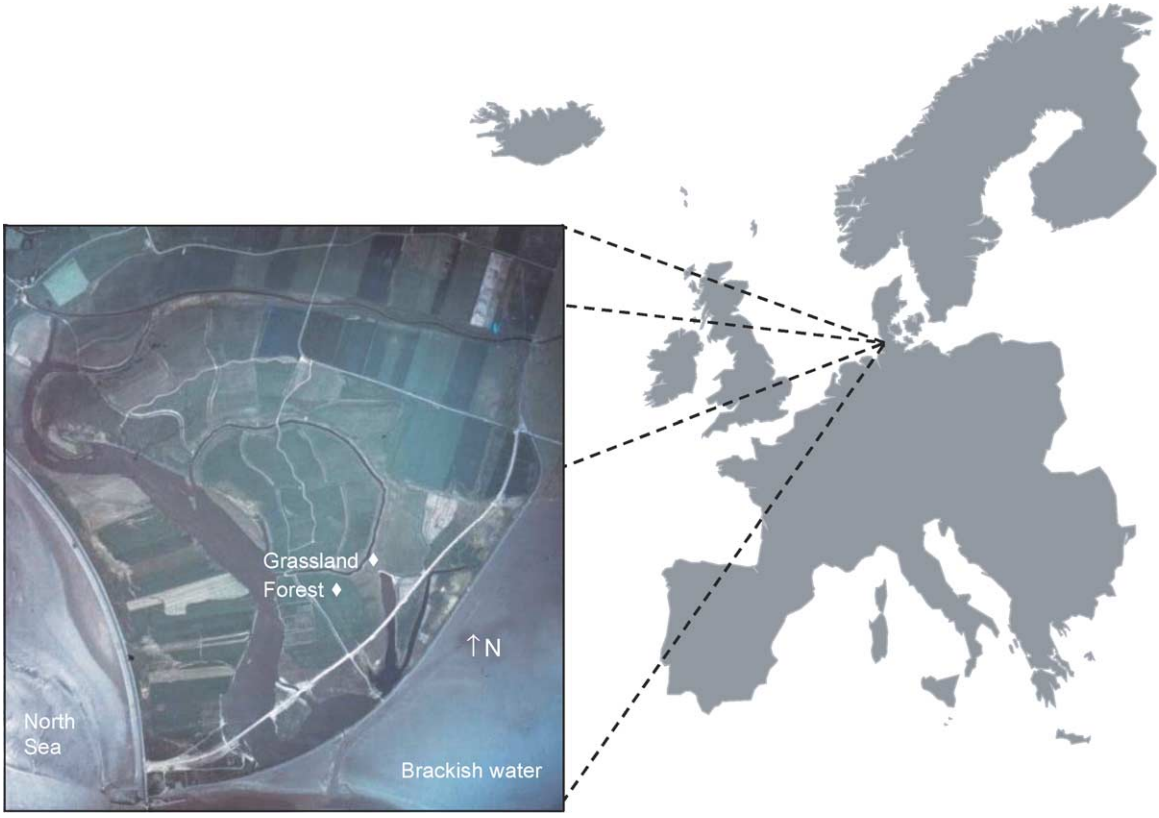

Fig. 1. Aerial view with the guiding sites of the grassland and *Quercus* forest at the Katinger Watt in Schleswig-Holstein, Northern Germany.

the late summer (during the last 6 years). The soil types were classified as Calcari-Epigleyic Fluvisols with calcium carbonate and reducing conditions within 50 cm of the soil surface (WRB, 1998). Soil texture varied with approximately 6% clay, 17–27% silt and 66–78% sand. In addition to the sampling at the guiding profiles, multiple soil cores were taken at four locations at the forest and grassland, respectively. After removal of living plant residue, soil was sieved at 2-mm mesh size. Material was dried for elementary analysis and stored fresh at 4 °C for microbial investigations not longer than 1 month. Humus chemistry with dry soil was done using density fractionation after Beudert (1988) using sodium polywolframate ($Na_6(H_2W_{12}O_{40})\cdot H_2O$; Fa. SOMETU, Berlin). Microbial respiratory activity was quantified with a Sapromat respirometer as described in detail by Dilly (2001). Since soil pH (H_2O) value ranged between 6.2 and 7.0 in the topsoils and from 6.7 to 7.8 in the subsoils, soil was preconditioned in the Sapromat in the presence of sodium hydroxide for 3 days to absorb abiotic CO_2. Thereafter basal respiration was determined for about 24 h, the alkali trap was exchanged and glucose added at the rate of 12.5 mg per g of topsoil and 5 mg for the subsoil to induce maximal initial respiratory response (MIRR). Substrate-induced respiration was measured for 4 h. Carbon dioxide values were used here.

Between 36 and 99 mg organic C g^{-1} soil were present in the A horizons after 30 years (Table 1). The A horizons had a thickness between 5–6 cm. The C_{org} content in the B horizon ranged between 2 and 4 mg organic C g^{-1} soil. In accordance, an average value of 2.4 mg organic C g^{-1} was recorded by Joergensen and Mueller (1995) for tidal flat sediments close to the nearby island Sylt. Thus, values in

Table 1
Abiotic characteristics of marshland soils under grassland and *Quercus* forest at the Katinger Watt in Schleswig-Holstein, Northern Germany

Site	Horizon	Thickness (cm)	pH value ($CaCl_2$)	Bulk density (mg g^{-1})	C_{org} (mg g^{-1})	Accumulated C (kg m^{-2})	<1.6 (%)	1.6–2.0 (%)	>2.0 (%)
Grassland	Ah	5	6.3	0.57	99	2.69	97	2	1
	B[a]	10	7.3	1.50	4	-	ND	ND	ND
Forest	Ah	6	6.9	0.83	36	1.69	89	6	5
	B[a]	9	7.5	1.55	2	-	ND	ND	ND

Abbreviation: Not determined ND.
[a] The B horizon is more that 30 cm thick but was only sampled for 9 or 10 cm.