Geophysical Research Abstracts
Vol. 14, EGU2012-5509, 2012
EGU General Assembly 2012

Depth distribution of soil organic carbon fractions and AMS 14C concentrations at different landscape positions

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On sloped arable land soil redistribution has a great impact on spatial patterns of soil organic carbon (SOC) stocks and on the lateral and vertical carbon fluxes between soil and atmosphere. While most studies focus on total SOC, the investigation of the impact of soil redistribution on SOC fractions and thus on different SOC quality can improve the knowledge about the processes controlling an erosion induced C sink or source. Some studies indicate that the labile SOC pool might be preferentially transported by water erosion, however others indicate that black carbon being considered as an inert pool is preferentially redistributed. Preferential erosion and/or deposition of specific SOC fractions must lead to a spatial differentiation of the SOC pool composition in areas prone to erosion. In this study we analysed differences in the depth distribution of particle-size SOC fractions and AMS 14C concentrations in relation to these fractions at different slope positions within an arable field in western Germany. Based on modelled soil redistribution, two soil profiles representing depositional, erosional and reference (with ignorable erosion or deposition) sites were analysed. Soil cores were taken to a maximum depth of 1.6 m and were divided into 0.05 m increments except for the actual tillage depth (0-0.15 m). For every second depth increment starting with the topsoil layer total SOC, particle-size SOC fractions and AMS 14C concentrations were determined. The fractionation scheme of Amelung et al. (1998) was applied resulting in three particulate organic carbon fractions (POC 1: 250 – 2000 μm, POC 2: 53-250 μm, POC 3: 20 -53 μm) and the remaining fine sized fraction (< 20 μm).

Combining POC 1 and 2, which are often assumed to represent the labile carbon pool shows a decline of SOC in these fractions from reference to erosional to depositional sites. This indicates (i) a preferential detachment of these fractions at erosional sites, while (ii) the more pronounced depletion at depositional sites may result from a multitude of processes, namely selective deposition, mineralisation during transport and/or enhanced mineralisation of the labile SOC pool. More than 80% of total SOC was stored in the fine-sized fraction commonly assumed to represent the passive SOC pool. For the topsoil layers the amount of this SOC pool was relatively similar at all slope positions, while it substantially differed in the subsoil layers. Throughout the depositional profiles the relative contribution of this pool remained relatively high proving a substantial stabilisation of SOC in the subsoil at depositional sites. The depth distribution of AMS 14C confirmed the observed differences in SOC pool composition at different slope positions. At the reference sites 14C decreased with depth indicating a relatively high amount of young plant residues in the topsoil and increasing amounts of more passive components in the subsoil. This decrease was more pronounced at erosion sites, whereas 14C content remained relatively high up to a certain depth at depositional sites hinting to burial and preservation of relatively recent SOC below the plough layer.

Our results show that soil redistribution not only leads to spatial patterns of total SOC, but also alters the SOC pool composition and 14C concentrations along soil profiles at different slope positions proving the usefulness of these data to improve the understanding of the involved processes.