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Impacts of Land-use Change on Organic Carbon Storage in Highly Weathered Soils of Tropical Sub-sahara Africa

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Abstract

Land-use change of tropical forests for agricultural production is considered as a major cause for soil organic carbon (SOC) decline. However, the extent of land-use change impact on SOC storage is highly uncertain, especially for tropical Africa. Interactions with the soil mineral phase can modify such impacts because of high contents of pedogenic oxides and clay in these highly weathered soils and their potential for C stabilisation. The aim of the study was to determine land-use change impacts on SOC storage for soils commonly found in tropical sub-Sahara Africa. For that purpose ten pedological similar soils in the Eastern Usambara Mountains (Amani Nature Reserve, NE Tanzania) under contrasting land uses were sampled down to 100 cm soil depth. Measured SOC stocks were 17.5 kg m^{-2}, 16.8 kg m^{-2}, 16.9 kg m^{-2} and 20.0 kg m^{-2} for forests, tea plantations, croplands and home garden, respectively. A significant decrease in mean SOC storage of 1.3 kg m^{-2} was detected after changing forests into croplands for the 0–10 cm depth increment. No further significant land use

impacts could be detected. All soils have a clay dominated texture and are characterised by high contents in pedogenetic oxides. No significant relationships could be detected between SOC and clay contents for the investigated soils. Statistically significant relationships were found between oxalate extractable Fe/Al and SOC contents for cropland soils only, although forest soils comprised a wider range of oxalate extractable Fe concentrations. Probably, a higher variability of fresh OC input in forests may obscure the relation between SOC and pedogenetic oxides under forests.

Based on our preliminary results, the role of clay minerals and pedogenic oxides for SOC stabilisation and the related mechanisms as the formation of mineral-associated organic matter (MOA's) and aggregation will be further studied in these tropical soils. For that purpose a large field campaign was done in the same study area in spring 2018 again. We used X-ray fluorescence spectroscopy (XRF) to define a natural gradient in the pedogenic metal oxides and clay content. The following hypotheses will be checked:

a) Increasing metal oxide and clay mineral content will result in larger amounts of SOM associated to the heavy fraction (HF), because of increasing availability of reactive surface groups.

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b) Increasing availability of net-positively charged metal oxide surfaces will lead to a larger stabilisation of SOM by formation of MOA's,

c) Increasing ratios in metal oxides to clay minerals content will lead to larger amounts of water-stable aggregates and consequently to increasing storage and stabilisation of SOM within aggregates.

Keywords: Land-use change, kaolinite, pedogenic Fe- and Al-oxides, SOC stabilisation, SOC storage, Tanzania