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Development of SOM and aggregation in an agriculturally managed re-cultivated loess

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Soil organic matter (SOM) and organic glues from biological processes are considered to be major contributors in aggregate formation. But there is limited knowledge on soil structural formation during initial soil development – the step when SOM content is low and soil properties are mostly controlled by the parent material. In our study we used a chronosequence approach in the re-cultivated open-cast mining area near Cologne, Germany to elucidate the development of soil structure and soil organic matter during initial soil formation in a loess material. We selected six plots with different ages of agricultural management after re-cultivation (0, 1, 3, 6, 12, and 24 years after first seeding). In each plot 12 spatially independent locations were sampled with stainless steel cylinders (100 cm³) at three depths representing the topsoil (1-5 cm), the plowing layer (16-20 cm), and the management-unaffected parent material (41-45 cm). All samples were analysed for bulk density, organic and inorganic carbon and total nitrogen content, and aggregate size distribution (≥ 20 mm, 20-6.3 mm, 3.6-2 mm, and ≤ 2 mm). We calculated soil organic carbon stocks during this early phase of soil formation and assessed the development of aggregation by determining the aggregate stability and their organic carbon content.

The re-cultivated soils in the area were alkaline and no differentiation was determined along the chronosequence with having an average $\text{pH}_{\text{CaCl}_2}$ of 7.5. The reclamation was established with freshly excavated loess, thus CaCO_3 content in the soil was relatively high having concentrations in management-unaffected parent material layer of 73.7 mg g⁻¹ in 0 year and 124.5 mg g⁻¹ in 24 years. Bulk density and soil organic carbon content showed different temporal developments. In just one year bulk density increased to an average of 1.6 g cm⁻³ and changed after first ploughing with remaining stable after 12 years to 1.5 g cm⁻³ from topsoil to parent material. Soil organic carbon content increased during first three years only in topsoil (1-5 cm). After ploughing fresh OM input was detected in 0-30 cm, where OC stocks increased from 1.23 kg OC m⁻² in 3 years to 4.06 kg OC m⁻² in 6 years. Although we detected OM input and an increase of OC concentrations in aggregates along the chronosequence, we did not see significant differences in aggregate size distribution. Due to high carbonate content in re-cultivated soils, CaCO_3 was dominating as a cementing agent and had a strong influence on aggregation in loess soil.