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Analysing Structure Dynamics in Arable Soils using X-ray Micro-Tomography

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Structure is a dynamic property of soil. It interacts with many biotic and abiotic features and controls various soil functions. We analyzed soil structure within different plots of the ”Static Fertilisation Experiment” at the agricultural research station in Bad Lauchstaedt (Germany) using X-ray micro tomography. The aim was to investigate in how far different levels of organic carbon, increased microbial activity and enhanced plant growth affects structural properties of an arable soil. Since 106 years one plot has experienced a constant application of farmyard manure and fertilisers, whereas the other has never been fertilised in this period. Intact soil cores from the chernozem soil at the two plots were taken from a depth of 5 to 15 cm (Ap-horizon) and 35 to 45 cm (Ah-horizon) to analyse structural changes with depth and in two different seasons (spring and summer) to investigate structure dynamics.

The pore structure was analysed by quantifying the mean geometrical and topological characteristics of the pore network as a function of pore size. This was done by a combination of Minkowski functionals and morphological size distibution. For small structural features close to the image resolution the results clearly depend on the applied filtering technique and segmentation thresholds. Therefore the application of different image enhancement techniques is discussed. Furthermore, a new method for an automated determination of grey value thesholds for the segmentation of CT-images into pore space and solid is developed and evaluated. We highlight the relevance of image resolution for structure analysis.

Results of the structure analysis reveal that the spring samples of the ploughed layer (Ap-horizon) from the fertilised plot have significantly higher macroporosities ($P < 0.05$) than those from the non-fertilised plot. The internal connectivity of the pore network is better in the fertilised plot and the pore size distribution was found to be different, too. The differences in porosity and pore connectivity increase from spring to summer. Both plots were compacted by a rolling machine in late winter. So the difference in structure dynamics is interpreted as an enhanced structure resiliency in the fertilised and carbon enriched plot after that compaction. A comparison with porosity features of a nearby reference profil under grassland demonstrates that the impact of tillage on pore structure is higher than the different contents in organic carbon.

The carbon enriched horizon beneath the ploughed layer (Ah-horizon) shows no differences in pore size distribution and connectivity as a function of fertilisation. Thus, at that soil depth, no long-term effects of fertilization in terms of soil structure are detectable. Obviously, the highly different energy input during 106 years only affects the structure of the top soil.