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Temporal evolution of the macropore network and saturated hydraulic conductivity in an arable, clayey topsoil during one growing season

Maria Sandin, Johannes Köstel, Nicholas Jarvis, and Mats Larsbo
Department of Soil & Environment, Swedish University of Agricultural Sciences, Box 7014, 750 07 Uppsala, Sweden

Soil macropore networks and thus hydraulic properties at and close to saturation vary considerably with time, as a result of the dynamic nature of a diverse range of interacting soil structure-forming and degrading factors such as tillage and traffic events, faunal and plant root activity, swell/shrink arising from wetting and drying cycles, freeze-thaw etc. These properties are nevertheless treated as constants in most hydrological modelling studies. This is mostly justified by a lack of understanding of the processes driving these changes. Temporal variations of saturated and near-saturated hydraulic conductivity have been studied in the field (e.g. by tension disc infiltrometer), but these measurements only indirectly reflect the characteristics of the macropore network. In this study, we used non-destructive X-ray tomography to investigate the temporal changes in the macropore network characteristics occurring in the harrowed layer of a conventionally-tilled agricultural field over one growing season. Undisturbed soil cores (60-70 mm height, 68 mm diameter) were sampled on five different occasions. Changes in the geometric and topological properties of the X-ray imaged macropore system (voxel resolution = 120 μm) were compared with variations in saturated hydraulic conductivity measured on the same samples.
Image analysis showed that total porosity, specific surface area, average pore diameter and the connectivity of the pore system in the uppermost 60-70 mm of ploughed and harrowed soil decreased from the first sampling occasion shortly after seedbed preparation and sowing until the middle of the growing season after which it slightly increased again. Separate analysis of the total porosity of the top 5 mm showed a marked decrease between the first two sampling occasions, followed by a gradual increase. Despite these structural changes in the macropore system, saturated hydraulic conductivity was only weakly correlated with macropore network characteristics.