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Assessing Tillage Effects on Soil Hydraulic Properties via Inverse Parameter Estimation using Tension Infiltrometry

Andreas Schwen (1), Gernot Bodner (2), and Willibald Loiskandl (1)

(1) Institute of Hydraulics and Rural Water Management, Univ. Natural Resour. Appl. Life Sci. BOKU Vienna, Austria (andreas.schwen@boku.ac.at), (2) Institute of Agronomy and Plant Breeding, Univ. Natural Resour. Appl. Life Sci. BOKU Vienna, Austria

Hydraulic properties are key factors controlling water and solute movement in soils. While several recent studies have focused on the assessment of the *spatial* variability of hydraulic properties, the *temporal* dynamics are commonly not taken into account, primarily because its measurement is costly and time-consuming. However, there is extensive empirical evidence that these properties are subject to temporal changes, particularly in the near-saturated range where soil structure strongly influences water flow. One main source of temporal variability is soil tillage. It can improve macroporosity by loosening the soil and thereby changing the pore-size distribution. Since these modifications are quite unstable over time, the pore space partially collapses after tillage. This effect should be largest for conventional tillage (CT), where the soil is ploughed after harvest every year.

Assessing the effect of different tillage treatments on the temporal variability of hydraulic properties requires adequate measurement techniques. Tension infiltrometry has become a popular and convenient method providing not only the hydraulic conductivity function but also the soil rentention properties. The inverse estimation of parameters from infiltration measurements remains challenging, despite some progress since the first approach of Šimůnek et al. (1998). Measured data like the cumulative infiltration, the initial and final volumetric water content, as well as independently measured retention data from soil core analysis with laboratory methods, have to be considered to find an optimum solution describing the soil's pore space.

In the present study we analysed tension infiltration measurements obtained several times between August 2008 and December 2009 on an arable field in the Moravian Basin, Lower Austria. The tillage treatments were conventional tillage including ploughing (CT), reduced tillage with chisel only (RT), and no-tillage treatment using a direct seeding technique (NT). Infiltration measurements were supplemented by retention data for dryer conditions (-10 to -300 kPa) as determined by pressure plate extraction on steel core samples. The HYDRUS 2D/3D software package was used to inversely fit the parameters of suitable soil retention models to the data. Beside the most common model of Van Genuchten (1978), we also assessed the lognormal distribution model proposed by Kosugi (1994) and the dual porosity approach of Durner (1994).

We will show that a dual porosity model best fits the infiltration data. It allows the retention curve to account for both the cumulative infiltration (structure-controlled flow) as well as the measured retention data points (texture-controlled flow). The pressure plate extraction data are used to determine one of the shape-determining parameter sets of the model equation. As the tillage effect on the temporal variability is expected to be negligible for texture-controlled water flow, these parameters are set constant with time for each tillage treatment. All remaining model parameters were inversely determined by the infiltration data.

The advantage of a bimodal retention model is greatest when macropores strongly contribute to water movement. This can be observed especially under conventional tillage, where a strong increase of macropores is caused by annual ploughing, but also for reduced (oder minimum) tillage treatments, where biopores from earthworm burrows and dead plant roots increase macropore flow.