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Thema
AG 3-4D Bodenmodellierung

3-4D Bodenmodelle zur räumlich-quantitativen Darstellung von Böden und Bodenlandschaften

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Titel
Coupled root water and solute uptake - a functional structural model

Abstract
Understanding the distribution and fate of solutes in the soil-plant continuum is of interest for regulatory authorities, customers and producers. For example pesticide legalization requires certain modelling and experimental studies before the substance can be released on the market. The modelling approach used in these procedures, however, does not hold detailed information about the fate of the solute in the plant root system, but treats the root system only as a linear sink term. Uptake is determined as fraction of transpiration of the concentration in the dissolved phase. With an increasing availability of more detailed modelling approaches within the last years, we focus on a more comprehensive description of pesticide uptake by plant roots. R-SWMS is a three dimensional model for water movement in soil and plant roots (1). It also includes solute transport within the roots, which is realized as a particle tracking algorithm (2). We coupled this model to Partrace, another particle tracking algorithm that solves the convection-dispersion-equation in the soil. Active or passive solute transport across the root membrane is possible. While active transport, namely Michaelis-Menten kinetics, requires energy input from the plant, passive transport can be either driven by advective water uptake and/or by the local concentration gradient between root and soil. Root membrane conductance is determined by the lipophilic properties of the solute. Within the root system solutes are transported via the advective water flux. We further implemented microbial decay and sorption to both soil and roots. Benchmarking the coupled 3D model with an analytical solution for a single root at steady state flow conditions showed a good agreement. Using this new approach we could derive global uptake parameters in silico and compare the simulation results to data from hydroponic experiments. The detailed modelling approach enables tracking solutes in time, space and phase within the soil and root system. This novel simulation tool can be used to investigate the influence of soil properties, root system architectures, solute properties, meteorological conditions as well as plant management strategies on plant solute uptake to gain a deeper understanding of solute uptake and transport parameters.

Literatur
[1] Javaux, M., et al., Use of a Three-Dimensional Detailed Modeling Approach for Predicting Root Water Uptake. Vadose Zone Journal, 2008. 7(3): p. 1079-1079.
[2] Huber, K., et al., Modelling the impact of heterogeneous rootzone water distribution on the regulation of transpiration by hormone transport and/or hydraulic pressures. Plant and Soil, 2014: p. 1-20.