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Numerical Simulation of Soil Water Movement in Variably Saturated Zone of Heterogeneous Soil Profile during Growing Period of Corn

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The natural conditions are very complex. All attempts to quantify them are leading to a kind of idealization. It is also obvious in the case of variably saturated zone of soil without macro-pores, as the part of hydrological cycle. The stated problem can be solved using a numerical simulation, which describes reality applying appropriate physical and mathematical simplifications. The mathematical model GLOBAL (Majercak, Novak, 1995) is one of them. It is based on the solution of Richards's equation. The model solves governing equation using the numerical scheme of finite elements.

The accuracy of outputs from a model depends besides its physical and mathematical structure mainly from the input data. The measurements were conducted in the corn field near Bratislava during the growing season of crop. The initial condition for simulation comprises from the first measurements of soil moisture in the variably saturated zone of soil profile at the beginning of growing season in the middle of March 2003. Before the simulation could start, it was also necessary to be familiar with the basic hydro-physical characteristics of soil, as the values of saturated hydraulic conductivity and the water retention curves for each soil layer. The values of soil moisture can be measured by various methods. The classical gravimetric method was applied, because the undisturbed samples in cylinders of known volume (100 cm^3) were needed also for measurements of the saturated hydraulic conductivity and the water retention curves. Firstly, the instant weight of the samples was measured. Then, all of the samples were saturated and the weight of saturated samples was measured. One part of the samples was used for determination of the water retention curves, and the other for measurements of the saturated hydraulic conductivity. The drainage branches of water

retention curves were determined using the overpressure devices. This process took three – four months. In the simulation was the hysteresis of the water retention curves neglected. The saturated hydraulic conductivity was measured using the method of falling head permeameter. At the end of the entire measurements were all of the samples dried in the laboratory kiln by 105˚C. After all these processes was possible to establish the initial condition for given numerical simulation. Owing to the measured hydro-physical characteristics (saturated hydraulic conductivity and water retention curves); the studied soil profile consisted of the set of roughly homogeneous soil layers. From the point of view of simulation, was therefore possible to divide the soil profile into several homogeneous parts with their own hydro-physical characteristics. The upper boundary condition was constituted by the climatic characteristics (daily precipitation total [mm.day^{-1}], mean temperature [˚C], sunshine duration [hours], vapor pressure [hPa] and mean wind velocity [m.s^{-1}]) measured at the meteorological station of The Slovak Hydro-meteorological Institute in Bratislava-airport, which is very close to the monitored site. The upper boundary condition also comprises of the phenological parameters (leaf area index [m^2.m^{-2}], roughness of evaporating surface [m], albedo of surface [cm], root depth [cm] and relative mean water content [%]) of vegetal cover formed by corn. The lower boundary condition could be defined by the time series of the ground water level depth, which was at the studied area very deep under the soil surface, or by the time series of the pressure head in selected depth of the soil profile at the monitored site.

The one-dimensional mathematical modeling of the continual change of moisture in vertical direction was performed. Presented simulation gave good information about the real state of water content at studied locality in comparison with the values counted from measurements. The values of saturated hydraulic conductivity constituted the most sensitive input into the used physically based model of water flow through the porous media. The variability of water retention curves at studied locality did not influence the simulation in such extent as the values of saturated hydraulic conductivity. Therefore it is necessary to choose the appropriate method of measuring of saturated hydraulic conductivity because of the wide range of natural conditions. It is also essential to know which method of the measurement of saturated hydraulic conductivity is suitable for used mathematical description of water flow in selected numerical simulation. Only then is the quantity of various numerical simulations used correctly.

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Reference:

Majercak, J., Novak, V. (1995): Global – a Numerical Model for Water Movement in

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