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Unsaturated flow dynamics during irrigation with wastewater: field and modelling study

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To deal with water scarcity combined with a growing water demand, the reuse of wastewater effluents of wastewater treatment plants (WWTP) for industrial and agricultural purposes is considered as a technically and economically feasible solution. In agriculture, irrigation with wastewater emerges as a sustainable practice that should be considered in such scenarios.

Water infiltration, soil moisture storage and evapotranspiration occurring in the unsaturated zone are fundamental processes that play an important role in soil water balance. An accurate estimation of unsaturated flow dynamics (during and after irrigation) is essential to improve wastewater management (i.e. estimating groundwater recharge or maximizing irrigation efficiency) and to avoid possible soil and groundwater affections (i.e. predicting contaminant transport).

The study site is located in the Experimental Plant of Carrión de los Céspedes (Seville, Spain). Here, treated wastewater is irrigated over the soil to enhance plants growth. To obtain physical characteristics of the soil (granulometry, bulk density and water retention curve), soil samples were collected at different depths. A drain gauge passive capillary lysimeter was installed to determine the volume of water draining from the vadose zone. Volumetric water content of the soil was monitored by measuring the dielectric constant using capacitance/frequency domain technology. Three soil moisture probes were located at different depths (20, 50 and 70 cm below the ground surface) to control the variation of the volumetric water content during infiltration.

The main aim of this study is to understand water flow dynamics through the unsaturated zone during irrigation by using the finite element model Hydrus-1D. The experimental conditions were simulated by a 90 cm long, one dimensional solution domain. Specific climatic conditions, wastewater irrigation rates and physical properties of the soil were introduced in the model as input parameters. Data from the lysimeter and soil moisture probes were used to calibrate the model. The overall simulation time period included the dry (irrigation as main source of water) and the wet season (precipitation as main source of water).

Future investigation concerning groundwater affections and contaminant transport at the field site will be based on the results obtained through the flow model developed in this study.