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In situ estimation of deep percolation in a dry area by concurrent measurements of soil water content and soil water potential

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Introduction

For sustainable groundwater management, groundwater extraction must be kept below natural groundwater recharge. Quantification of natural groundwater recharge may be assessed either locally from groundwater fluctuations or for the whole catchment area by analysing low water discharge of it's

outlet. In many cases groundwater fluctuations may be influenced by massive but unknown water extraction and do not reflect natural conditions, and results of analysing low water discharge will not be representative to the area of interest within the whole catchment basin. Physically based simulation models could help to overcome such shortcomings, being able to predict unknown natural ground water recharge from well-known weather-, soil- and cropping- data. Such models have to be validated using measured deep percolation, either from lysimeters or from indirect flux measurements as described in this paper.

Material and Methods

Systematic measurements of soil water content at each 10 cm down to 160 cm by the TDR- method and of soil water suction at 10, 20, 30, 40, 50, 70, 100, 120, 140 and 160 cm depth by calibrated gypsum blocks have been carried out at a natural grassland site on the high terrace of the "Marchfeld plain" east of Vienna since November 2002. The sensors had been installed at the front wall of an open soil pit by pressing them into the undisturbed soil. During excavation of the pit undisturbed soil samples had been taken at depths representative for 0-40, 40-90 and 90-180 cm, which horizons had been judged to be more or less uniform. Hydraulic conductivity and pore size distribution of these samples, as well as grain size distribution of additional, but disturbed samples were measured in the laboratory. Calibration of the WATERWISE gypsum blocks (Richardson & Mueller-Beilschmidt 1988) and WATERMARK Granular Matrix Sensors (Eldredge et al. 1993) had been performed by measuring sensor resistances at several pressure levels using suction equipment up to 50 kPa and pressure chambers up to 1500 kPa.

Sensor resistances measured in the field were corrected to 20 ˚C by an empirical formula (Stenitzer 1993) according to the ambient soil temperatures, which had been also measured at 10, 20, 30, 50, 100 and 160 cm, and resistances were then converted to soil suction using individual calibration curves for each sensor. Combination of these soil water suctions with water contents at same depths yielded field pF-curves, which were extrapolated in accordance with the laboratory pF-curves of the respective soil horizons. Capillary conductivity functions for each layer were estimated according to the method of Millington & Quirk (Bouwer & Jackson 1974), by which the shape of the capillary conductivity is derived from the shape of the pF-curve , passing through the saturated hydraulic conductivity measured in the laboratory.

For assessment of the percolation flux at the lower boundary capillary conductivity function of the soil layer at 160 cm was fitted to match both the measured saturated hydraulic conductivity as well as some rough estimation of the mean capillary conductivity at this depth during a drainage period in February 2003. Deep percolation and capillary rise were estimated according to Darcy's law, multiplying measured suction gradient between 140 and 160 cm by capillary conductivity at the ambient water content. Calculated accumulated deep percolation was checked during winter periods by comparison with measured decrease of soil water storage, assuming actual evapotranspiration to be 10% of the potential one, which had been calculated from daily weather data using the Penman-Monteith approach (Allen et al. 1998).

Results

Deep percolation was calculated to be 170mm during October 2002 to May 2003 and 230 mm during February 2003 to June 2004; capillary rise took place from June 2003 to end of January 2003 amounting to 40 mm. Effective natural groundwater recharge from October 2002 to June 2004 therefore was 360 mm: this is about 38 % of the total precipitation of 947 mm during that period.

Examination of the calculated deep percolation by simple soil water balance for selected winter months with negligible evaporation yielded the following correlation:

$y = 0.9809\ x – 2.1$

$r^2 = 0.9344$

x = (rainfall – evapotranspiration – change in soil water storage)

y = calculated deep percolation

Conclusion

On condition that good measurements or estimates of the capillary conductivity function of the soil layer at the lower boundary of a soil profile are available, deep percolation may be assessed by continuous measurement of water content and suction gradient at this depth, which should be situated well below the deepest roots. Thus performance of simulation models on soil water balance could be tested, and models could be applied to predict the effects of land use changes upon ground water recharge or to estimate long term ground water recharge of an area of interest..

References

Allen, R. G., L. S. Pereira, D. Raes & M. Smith (1998): Crop evapotranspiration. Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper 56. Food and Agricultural Organization of the United Nations. Rome

Bouwer H. and R.D. Jackson (1974): Determining soil properties. In: Schilfgaarde J. van (Ed.) Drainage for agriculture. Agronomy Series 17, American Society of Agronomy, Madison, Wisconsin, U.S.A, pp. 611- 672.

Eldredge, E. P., C.C Shock,. & T.D. Stieber (1993): Calibration of Granular Matrix Sensors for Irrigation Management. Agron. J., 85:1228-1232

Richardson, G. & P. Mueller-Beilschmidt (1988): Winning with water. Soil-moisture monitoring for efficient irrigation. INFORM, Inc. New York.

Stenitzer, E. (1993): Monitoring soil moisture regimes of field crops with gypsum blocks. Theor. Appl. Climatol. 48, 159 – 165.