Field sensors and solutions for soil water monitoring

Georg von Unold[1]
[1] UMS GmbH, Gmunder Strasse 37, 81379 Munich, Germany

Abstract

Water is driven directly depending on the matrix potentials, as water will always move from areas of higher potential to areas of lower potential. Main water flow occurs at low tensions where only Tensiometers measure directly and precisely. The first part of this presentation shows how they work and which are the new and proven techniques of self refilling tensiometers and cavitation tensiometers. A short excurs shows matrix sensors and the principle differences to tensiometers.

Keyword

tensiometer, waterflux, vadoze zone, matrix potential, self refilling tensiometer, cavitation tensiometer, lysimeter

1. Introduction

Water is driven directly depending on the matrix potentials, as water will always move from areas of higher potential to areas of lower potential, in soils as well as on surface (Durner and Or, 2005). Main water flow occurs at low tensions where only Tensiometers measure directly and precisely. The first part of this presentation shows how they work and which are the new and proven techniques of self refilling tensiometers and cavitation tensiometers. A short excurs shows matrix sensors and the principle differences to tensiometers.

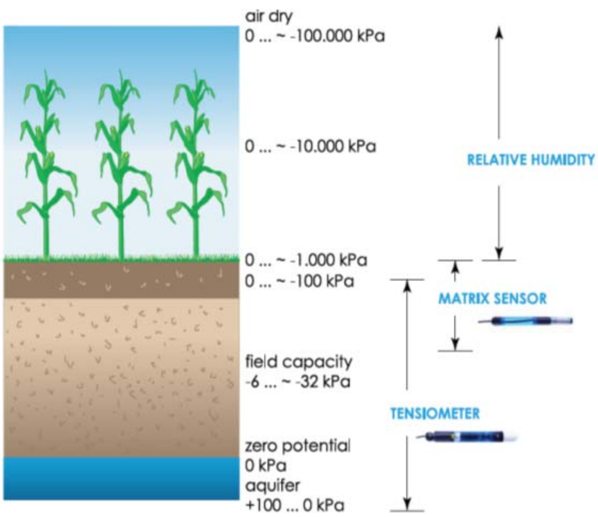

Fig. 1: Water potentials; aquifer, soil, root zone and air

2. Method

Plants take up water only if the air water potential is lower than the soil water potential (Fig. 1). They control the potentials and fluxes by their stomata at the leaves and roots. If soil gets too dry the potential is too low to take up water, which causes a water stress situation for plants. If soil is too wet roots will be damaged due to the missing air and oxygen. So the knowledge of the soil water matrix potential is essential for plant research and any scientific task related to the water fluxes in soils (Or and Wraith, 2002). Those we can measure directly with tensiometers. How do tensiometers work: Soil water and Tensiometer water have hydraulic contact through the porous ceramic. The soil water tension is directly conducted to the pressure transducer which offers a continuous signal. The atmospheric reference pressure is provided through a membrane on the cable. Big disadvantage of tensiometers is their small measure range -85 kPa … +100 kPa. This range covers the main water fluxes, but soil gets drier and after a dry period tensiometer needs to be refilled.

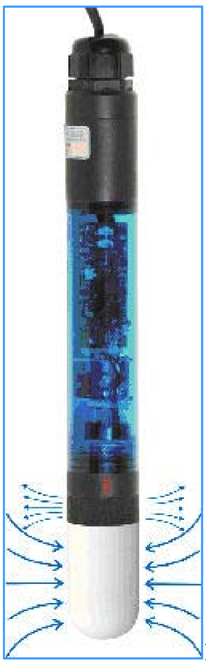

Fig 2: self refilling tensiometer

There are two exceptions. The TS1 tensiometer (Fig.2) has an embedded bubble controlled peristaltic pump to refill itself when soil is wet enough again. The UMS Mini tensiometer T5 can be filled in a way to work in the cavitation range – 85 kPa up to -300 kPa.

Matrix sensors are indirect sensors, based on a porous hydrophilic structure which is in hydraulic contact to the soil. This matrix needs to get into equilibration with the soil matrix potential. In case of a rain event the matrix sensor needs to saturate, - to take up water. The uptake speed depends on the hydraulic conductivity and the porouse volume. Inversely if the soil dries, the sensor matrix removes water to the soil until it reaches equilibration. They measure amount of water in the porous matrix capacitively or by other principles. These sensors are maintenance free and cover a larger range, but their precision is lower than the precision of pressure transducer tensiometers, as the charge and discharge of water takes time and has some effects like hysteresis.

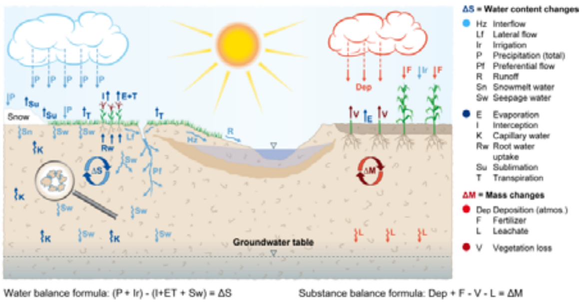

Fig. 3: Water and substance balance in soils

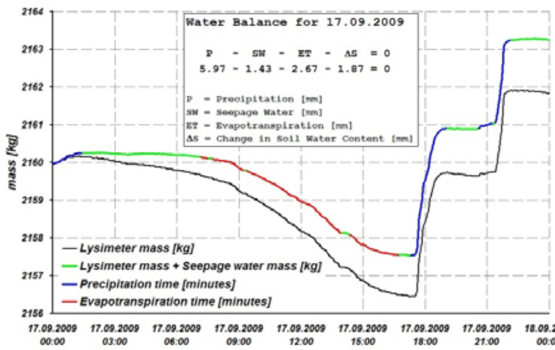

Fig. 4 Water mass determination

3. Results and discussion

The second part focusses on soil water fluxes, which can be monitored by tensiometer profile and the Richards equation or others. The calculation is based on knowledge of potential differences and conductivities and the assumption that those are constant in the covered horizons, which is in natural soils typically not the case.

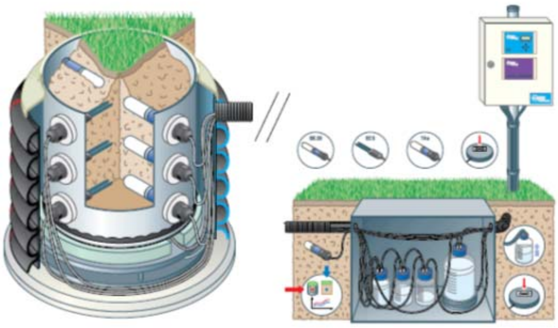

Fig. 5 Field design of a Smart field lysimeter

A complete small weighable and tension controlled field lysimeter, combined with matrix potential sensors, FD-probes and thermosensors, data logger, optional GPRS modem and powered by solar panels, this is the idea of the SMART FIELD LYSIMETER (Fig. 5). Lysimeter surface and depth could not be large enough (Fig.4), but this small setup gives information onwater and solute balance issues as lysimeters do. To excavate the undisturbed soil monoliths we need special techniques. For smart field lysimeters a special tool set is available.

Lysimeters with controlled hydraulic boundaries true to field situation can directly measure these fluxes. They are a tool to measure the hydraulic interface to atmosphere: If their weight increases we have rain, due, snow or hoar frost. A loss of weight means evapotranspiration. A loss of weight is also caused by the drainage water amount. Therefore this part is measured by a second balance.

4. Conclusion

Tensiometers are good sensors to measure precisely the matrix potential of water in soils, but require maintenance and measure not in dry situations. They work as piezometer as well. Matrix sensors cover a larger unsaturated range and are maintenance free, but have less accuracy especially close to saturation. 3rd generation lysimeters measure precisely water fluxes and solute transport in soils and they measure the hydraulic interfaces to atmosphere and to the groundwater.

References

Durner W. and Or D. (2005), Soil Water Potential Measurement. In Encyclopedia of Hydrological Sciences. 73.

Or D. and Wraith J.M. (2002) Soil water content and water potential relationships. In *Soil Physics Companion*, Warrick A. (Ed.), CRC Press: Boca Raton, pp. 49–84.

UMS Inc. Munich, Germany, (http://www.ums-muc.de/), produce a variety of high-quality tensiometers, including the new self-filling type TS1.