ESTABLISHMENT OF A LYSIMETER STATION FOR URBAN WATER STUDIES

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Introduction

Precise determination of water fluxes in the soil–plant–atmosphere continuum is of special interest in agro-hydrology. Weighing lysimeters provide critical information for water balance studies, including accurate determination of precipitation, evapotranspiration and deep percolation. The most advanced approach uses pressure-controlled porous plates at the bottom, regulated by a tensiometer installed in the field, allowing the lower boundary conditions to replicate field conditions accurately. In this paper we present the establishment of a fully functioning scientific lysimeter station located at Biotechnical Faculty, University of Ljubljana.

Fig. 1: Excavation of the lysimeters for renovation in September 2023 (foto: J. Ferlin).

Materials and methods

The lysimeter station (46°02'55.0"N, 14°28'18.4"E) is located in grassland at the experimental field of the Biotechnical Faculty, University of Ljubljana, Slovenia, at an altitude of 295 m. The Glinščica stream flows approximately 220 m north of the station. The soil is classified as Eutric Gleysol according to the World Reference Base for Soil Resources. The station consists of two weighing lysimeters positioned 14 m apart, with a service well located between them. Each lysimeter (UMS GmbH, 2012) is 1.5 m deep with a surface area of 1 m². The lysimeters are mounted on three weighing cells with a resolution of 100 g. Leachate is collected and weighed in a separate outflow tank located in the service well, with a resolution of 10 g. The mass of the soil monoliths and the leachate are measured every minute.

The soil columns within the stainless-steel frames are undisturbed soil monoliths obtained from Eutric Cambisol, formed on sandy gravel deposits of the Sava river, in a field above the Ljubljana aquifer, in the vicinity of Kleče water pumping station (46°05'41.2"N, 14°29'39.5"E).

Lower boundary conditions are controlled and are intended to replicate field conditions. Water movement is regulated based on continuous measurements of soil matric potential at 140 cm depth in both the soil monolith and the field. Water is either pumped from the lysimeter to the ouflow tank if the lysimeter has a less negative matric potential than the surrounding field soil, or vice versa if the matric potential in the field is less negative. However, the latter case usually occurs due to the heavy soil texture and high saturated zone in the field, compared to the lighter-textured soil monoliths, which contain a high abundance of stones in the deeper layers.

The lysimeter station was originally established in 2013. However, in 2016, a flood at the experimental field disrupted its proper functioning. In autumn 2023, renovation of the station began, which included replacing weighing cells, individual sensors, suction cups, pumps, and various tubes (Fig. 1). Additionally, due to leakage, the lower covers and seals of both lysimeters were also replaced in December 2024.

Results

Based on measurements of soil water matric potential in the lysimeter (L) and in the field (F), we identified a problem with the lower boundary conditions. This issue was related to the high saturated zone in the field and differences in soil properties between the soil surrounding the lysimeter and the soil monolith in the lysimeter. During spring, following periods of heavy precipitation, water in lysimeter L1 remained trapped in the suction cups and was not pumped to the outflow tank (Fig. 2).

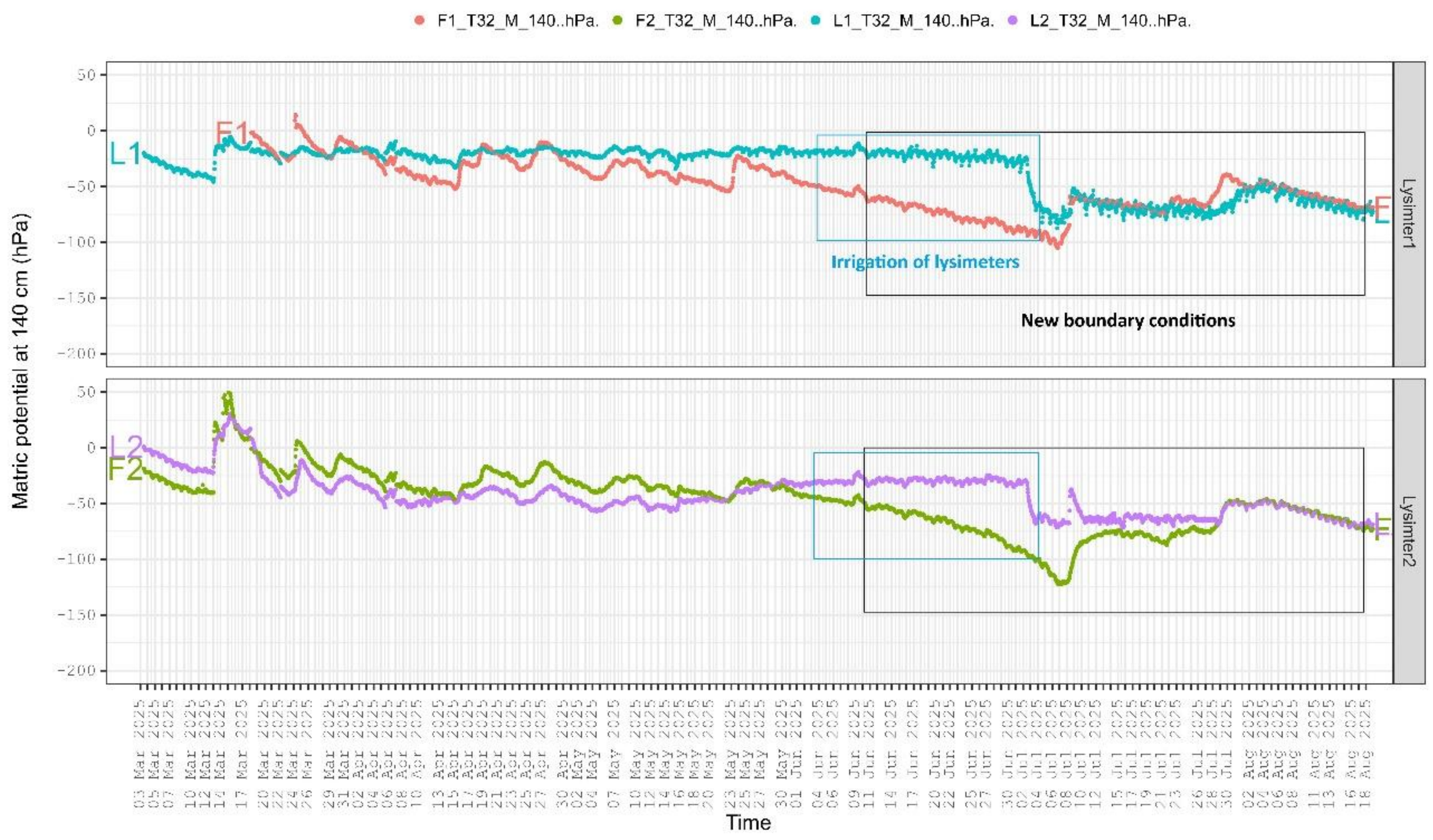

Fig. 2: Soil matric potential in the lysimeters and in the field at a depth of 140 cm.

We compared precipitation and evapotranspiration obtained from the Slovenian Environmental Agency (ARSO) at the nearby Ljubljana Bežigrad meteorological station, which is calculated using the Penman-Monteith equation (ARSO, 2025), with evapotranspiration measured directly by the lysimeters (Fig. 3).

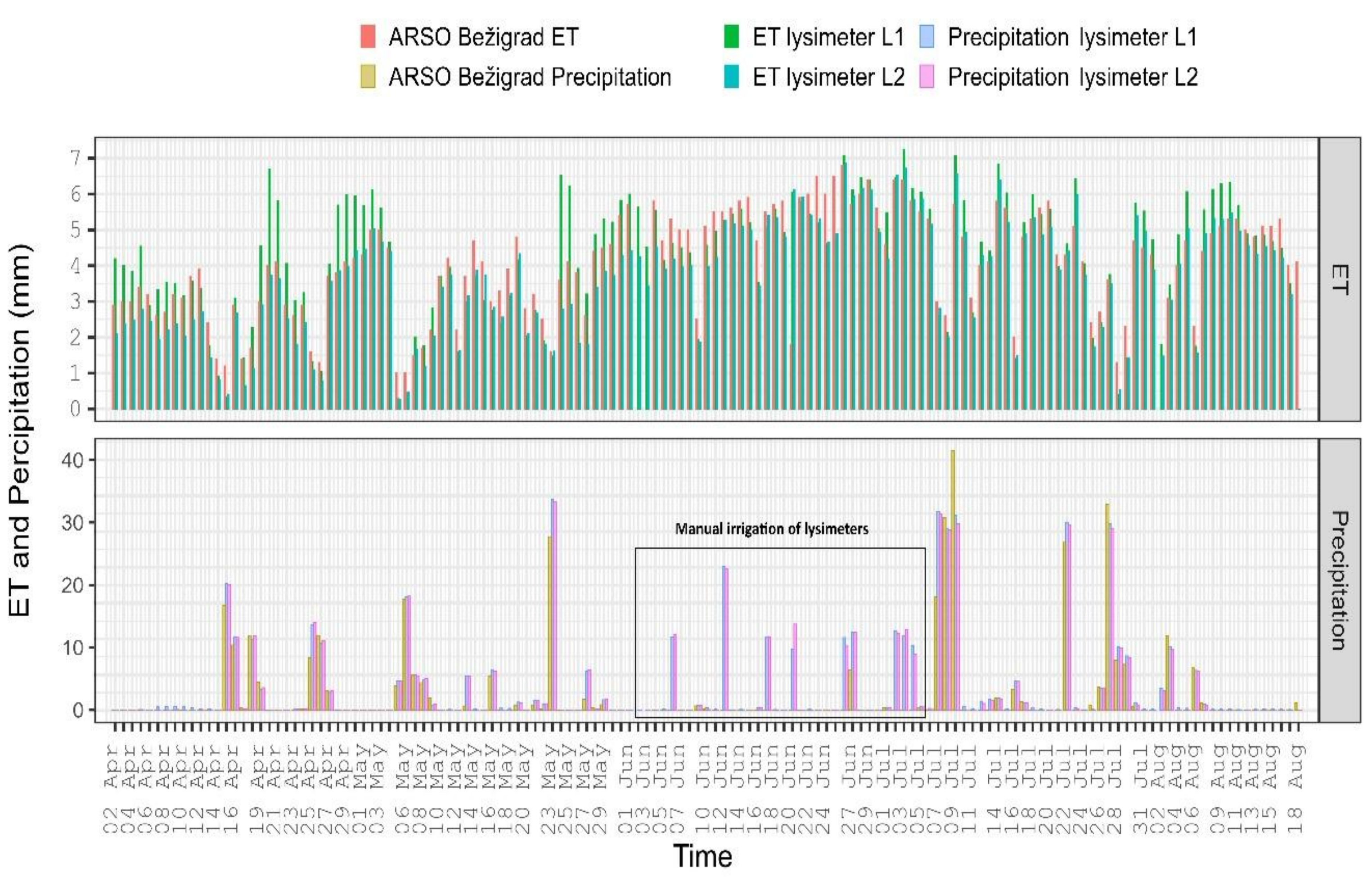

Fig. 3: Precipitation and evapotranspiration of lysimeters and obtained from meteorological station Ljubljana Bežigrad (ARSO, 2025). .

Conclusions

After the renovations, we tested the system by monitoring the mass of the lysimeters and the leachate collected in the outflow tanks. In one lysimeter, the outflow tank did not gain mass due to the configuration of the lower boundary conditions. Although these had been set to match field conditions based on continuous measurements of matric potential at 140 cm, they proved suboptimal because the high saturated zone of the surrounding soil prevented water from being pumped from the lysimeter to the outflow tank. After adjusting the lower boundary conditions, the lysimeter's measured precipitation and evapotranspiration aligned much more closely with the data from a nearby meteorological station.

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