Development of a

Weighing Forest Floor Grid-Lysimeter with Continuous Measurement of DOC

HYDROLOGY

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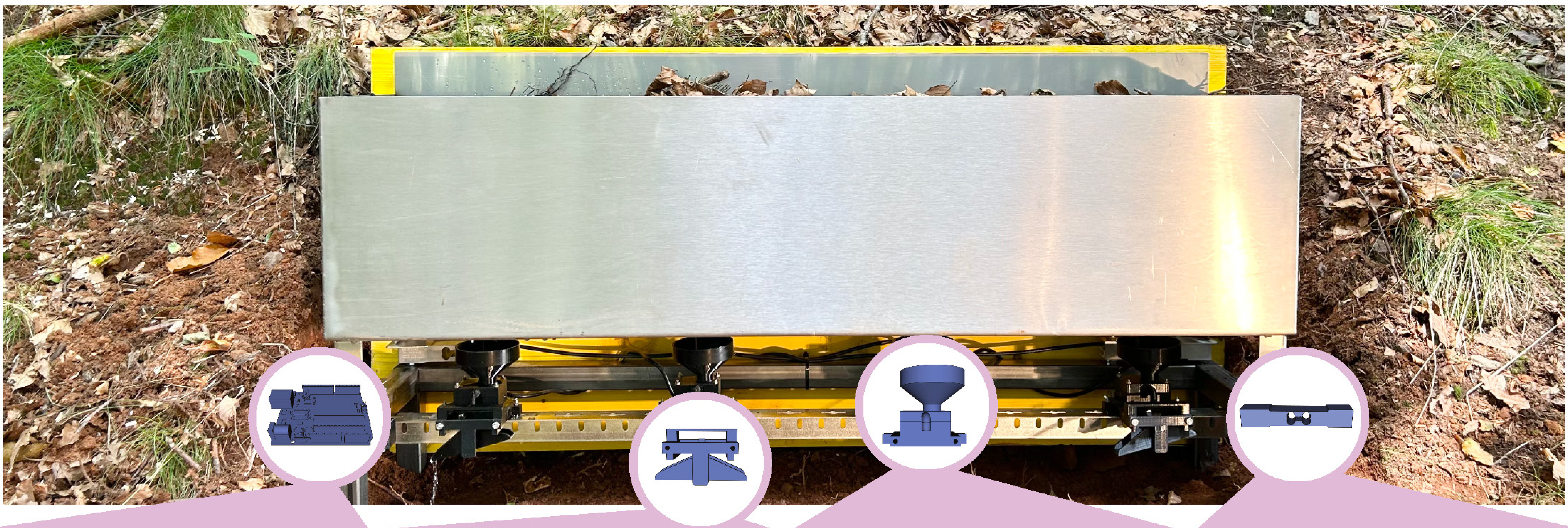
Motivation

The Forest Floor (FF) is hydrologically highly relevant but remains only partly explored. Especially in the O-Layer water repellency can be strong and seasonal highly variable. This variability influences infiltration patterns and may enhance bypass flow. Additionally, the leaching of dissolved organic carbon (DOC) from the FF is essential to quantify its carbon balance.

Since direct observations of water and DOC fluxes are missing, the goal was to develop a **weighing Forest Floor Grid-Lysimeter (FFGL)** with continuous measurement of DOC.

Background

- Litter interception has a huge influence on the water balance: it alters quantities of water available for soil infiltration and runoff [1]
- Litter interception is often disregarded, combined with transpiration or taken as a fixed percentage, but it can account for 20-50 % of the precipitation [2]
- Typical canopy ecosystem services like carbon sequestration, water infiltration, filtration, soil erosion control and biodiversity should also be attributed to the FF [1]
- Analysing lysimeter seepage water for DOC concentrations in-situ could be a great improvement compared to collecting and testing bulk samples in the lab



Microcontroller

The FFGL is run by a customized MKR Zero microcontroller board. It allows to connect:

- 4x load cells
- 4x tipping buckets
- 4x photodiodes
- 4x LEDs (adjustable intensity)
- 4x electrical conductivity sensors (EC)
- 4x temperature sensors

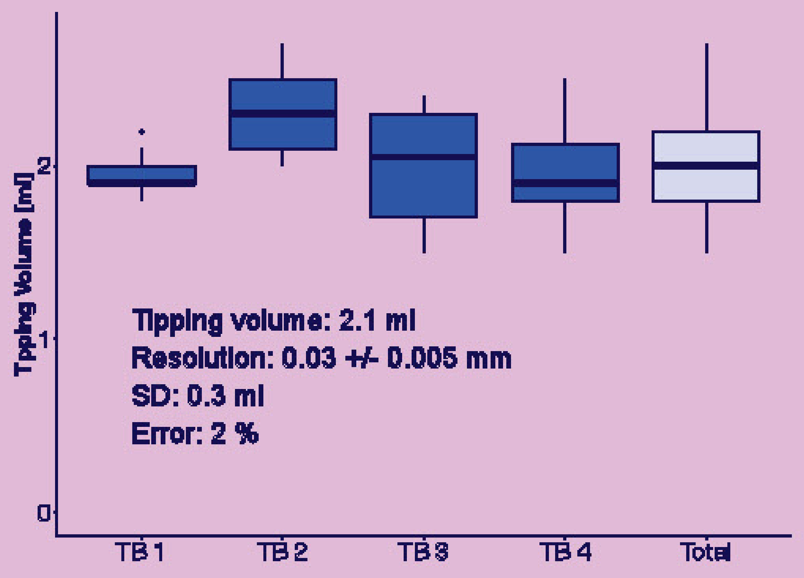
The sensors can be read in different timesteps. In combination with event-based programming and depending on the electrical power supply, data can be collected more often (i.e. every minute) during rain events and less often (i.e. every 10 minutes) in drier time periods.

The collected data is saved to a SD-card. Additionally, there is the option to transfer data via SDI-12 and connect several lysimeters to one master controller and transfer data remotely via modem.

The lysimeter is designed to generate data in a high spatial and temporal resolution. Therefore we needed a low-cost setup to install several lysimeters at one study site.

Tipping Bucket

The tipping bucket (TB) consists of a 3D printed bucket and frame. These parts are connected with a thin aglet. Further parts are a magnet and a reed switch.



Tipping volume (n=40) of four different TBs of one lysimeter.

The accuracy test shows small differences between the different TBs due to unevenness caused by the 3D printer. Compared to other TBs installed in rain gauges the accuracy is comparable and acceptable.

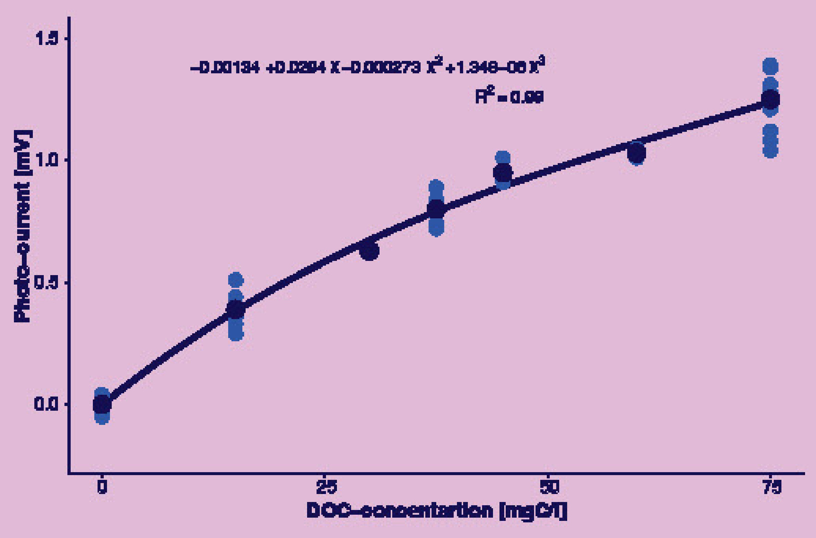
Scan the QR code for a nice video of the lysimeter in action!

DOC Measurement

The DOC measurement works via fluorimetry. The water sample is illuminated with a LED at 370 nm wavelength. Thereby DOC starts emitting fluorescence light at wavelengths between 450 and 520 nm. This light is then detected at a 90° angle to the LED through a band filter by a photodiode.

The intensity of fluorescence light and DOC concentration are correlated. With a site-specific calibration DOC concentrations between 0 and 100 mg C/l can be determined.

For the accuracy of optical sensors, it is indispensable to have clean visuals. Therefore the measurement chamber is shaped like a siphon to prevent drying out and to remove possible biofilm the unit is designed to allow easy access for cleaning.

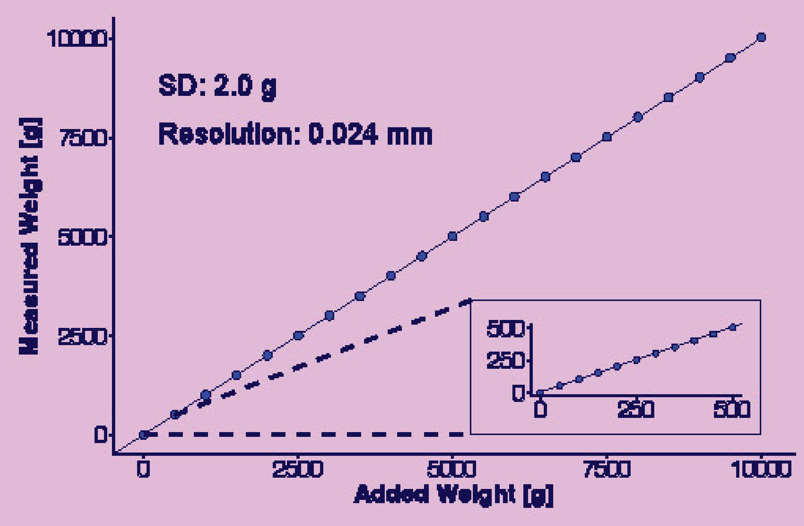


Polynomial regression for the relationship between photointensity and DOC-concentration.

Load Cells

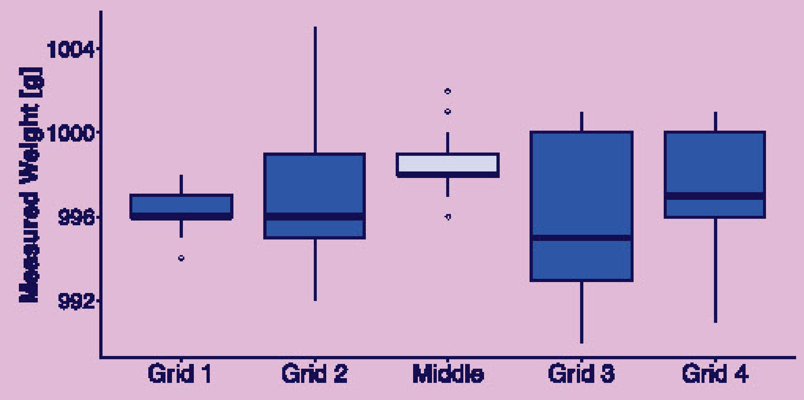
The load cells (LC) have a resolution of 6 g. After calibration, they show good accuracy.

The LCs show a temperature dependency. This will be corrected using various temperature sensors in and on the FFGL.



Comparison of measured and added weight (n=20).

The position of the weight in the lysimeter has a slight influence on the measured weight. The pressure should be distributed evenly for accurate results.



Same weight at different positions in the lysimeter (n=20).

Conclusion

We could show that our FFGL allows for detailed quantification of water fluxes of the Forest Floor in a low-cost setup. The minimum resolution for rainfall detection lies at 0.024 mm, whilst the quantification of seepage water is 0.03 mm.

The DOC measurement shows some difficulties in accuracy, but holds great opportunities to observe DOC flux dynamics.

Outlook

- Further testing of the device in the field is still necessary.
- We will compare different water and DOC fluxes of the FF under different conditions (e.g. tree species, climate, FF composition).
- We want to contribute to the overall understanding of FF processes, properties and services.

Literature

[1] Guevara-Escobar, A, E Gonzalez-Sosa, M Ramos-Salinas, and G D Hernandez- Delgado. 2007. "Experimental Analysis of Drainage and Water Storage of Litter Layers." Hydrol. Earth Syst. Sci.

[2] Gerrits, A. M. J., H. H. G. Savenije, L. Hoffmann, and L. Pfister. 2007. "New Technique to Measure Forest Floor Interception – an Application in a Beech Forest in Luxembourg." Hydrology and Earth System Sciences 11 (2): 695– 701. https://doi.org/10.5194/hess-11-695- 2007.

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