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► To cite this version:

Katharina Fuchs, Lothar Fuchs, Mathieu Lepot, Gislain Lipeme Kouyi. Soil moisture measurement in a Swale for SUDS modelling improvement. Novatech 2023, Jul 2023, Lyon, France. hal-04185040

HAL Id: hal-04185040

<https://hal.science/hal-04185040v1>

Submitted on 22 Aug 2023

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Soil moisture measurement in a Swale for SUDS modelling improvement

Amélioration des modèles d'infiltration dans les ouvrages de gestion à la source à partir de l'exploitation des mesures de la distribution spatiale de l'humidité du sol dans une noue

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RÉSUMÉ

La modélisation hydraulique et hydrologique du fonctionnement des ouvrages de gestion à la source représente un défi important du fait de la complexité à prendre en compte les processus en jeu. La modélisation de ces processus nécessite de définir un certain nombre de paramètres, en particulier ceux permettant de simuler l'évolution spatio-temporelle de la teneur en eau. Pour améliorer ces modèles, des expériences ont été menées au niveau d'une noue équipée d'un dispositif de mesure de débit à la sortie. Des capteurs de mesure d'humidité du sol ont été installés à différentes profondeurs. Un dispositif original d'alimentation de cette noue a été développé dans le but de simuler des eaux de ruissellement lié aux précipitations de différentes périodes de retour. Le débit entrant et l'humidité du sol ont été mesurés sur une semaine. L'objectif est d'exploiter ces données pour améliorer la capacité des modèles à simuler l'évolution de la teneur en eau dans les sols des ouvrages de gestion à la source, notamment lorsqu'ils sont sollicités par des événements extrêmes du fait du changement climatique. Les résultats sont en cours de consolidation et seront présentés lors de la conférence si notre article est retenu.

ABSTRACT

The hydraulic and hydrological modeling of Sustainable Urban Drainage Systems (SUDS) represents a major challenge due to the complexity of taking into account the processes involved. The modeling of these processes requires the definition of a certain number of parameters, in particular those allowing the simulation of the spatial-temporal evolution of the soil moisture. In order to improve these models, experiments were conducted on a swale equipped with a flowmeter at the outlet. Soil moisture sensors were installed at different depths. An original device for the irrigation of the swale was developed in order to simulate runoff water linked to rainfall of different return periods. The inflow and soil moisture were measured over a week. The objective is to use these data to improve the capacity of the models to simulate the evolution of the water content in the soils of SUDS, in particular when extreme events due to climate change occur. The results are being consolidated and will be presented during the conference if our paper is accepted.

KEYWORDS

Experiments, infiltration, soil moisture, SUDS, swale

1 INTRODUCTION

The modelling of SUDS in hydraulic models comes with major challenges. The various elements of SUDS are difficult to parameterize or cannot be modeled adequately (Wang, 2020). Often, there is a lack of flexibility in existing software or the appropriate input data (Ferrans et al., 2022). There is a need to collect more accurate data in the field or during laboratory experiments and use these records as an input to improve the models. Using existing data, only rough guidelines for parameterization can be assumed, which contain large uncertainties (Yang et al., 2021). This parameterization using literature values cannot be used to develop simpler and better models or to improve existing models (Ferrans et al., 2022, Kanso et al., 2018). Especially in the area of soil moisture or in soil properties, there is a large spatial variability that has not received much attention, yet (Kanso et al., 2018). Likewise, few studies have examined the operation and effectiveness of SUDS during extreme precipitation events. Statements about the effectiveness and the operation of SUDS during extreme events have largely been made based on computational results, without consideration of post-precipitation processes (e.g., recovery time) (Fiori & Volpi, 2020, Yin et al., 2020).

As part of the In-Situ SUDS Modeling project, experiments were conducted to measure soil moisture in a swale during defined, artificial precipitation events. The aim of the project is to obtain conclusions about the effectiveness of a swale during extreme events based on the generated measured values. Based on the multitude of measured values over a period of one week, the decline curve, i.e. the recovery of the soil after the events, will also be recorded. The aim is to simplify the parameterization of the depression in models and to better reproduce the corresponding infiltration processes, which also take place after an event. It is also expected that not only the vertical flow direction of the water in the soil, but also the horizontal flow direction can be better recorded. It is also expected that the results of the tests will also allow possible conclusions to be drawn about the interaction between the swale and the subsurface, in order to be able to estimate potential interaction between SUDS and groundwater.

2 MATERIAL AND METHOD

2.1 Materials

First, the calibration of the total of 24 soil moisture sensors TEROS 10 (Meter Environment) was carried out based on the soil samples in the laboratory. Likewise, the "sprinkler system" was built before the tests were carried out. The inflow of the swale is done by means of slotted PVC-U pipes DN 100. These pipes were slotted every 10cm with a slot length of 70mm and a slot width of 6mm.

Before starting the tests, the soil moisture sensors were installed in the swale. The layout diagram of the sensors is given in Figure 1. The soil moisture sensors were installed at different depths. The depths vary between 0.035m and 0.395m, whereby the sensors were installed at the edge of the swale close to the surface and those in the middle were installed deepest.

The irrigation system was built as a frame of PVC-U pipes at the edge of the swale. The slotted sections were installed along the length of the swale so that the inflow would occur at the side of the swale as in a natural occurrence. The profiles were closed along the short side of the swale. The individual PVC-U pipes were connected to each other with sockets, push-in joints and angles. The inflow to the sprinkler system was provided by the local tap system. For this purpose, the nearest hydrant was connected with hoses. The connection of the end hose to the system was made via a PVC-U pipe DN100 which ended in a flow meter with DN70. The flow meter was connected to the rest of the system via a T-profile and thus formed the inflow to the sprinkler system. The individual connections between the various parts were made using sleeves and connecting brackets.

2.2 Protocol

Before the actual tests were carried out, the well was first completely saturated. The swale was filled a total of three times. On the first day, the swale was filled twice to ensure that the sensors generated data and the irrigation system was checked for proper functioning. On the day of the actual tests, the swale was also filled completely beforehand. During this, the sprinkler system was optimized and the constant inflow to the system was ensured. Between the individual fillings, the swale was completely emptied.

In the two tests, the swale was filled with previously defined quantities of water over a period of 60 min. The aim of both tests is to be able to reproduce the behavior of a swale during an extreme precipitation event when it is already saturated. In the first test, 5 L/s were supplied to the swale in 60 min. Afterwards,

the swale was completely emptied again. For the second test, the inflow to the swale was set at 2.5 L/s in 60 min to keep the lower inflow of 2.5 L/s constant. For the second test, some of the slots had to be closed. Thus, only every 4th slot remained open to half of the swale. This ensured a constant water pressure. In both tests, the throttle at the outlet of the swale was open, so that the discharge in the measuring shafts behind it could be determined.

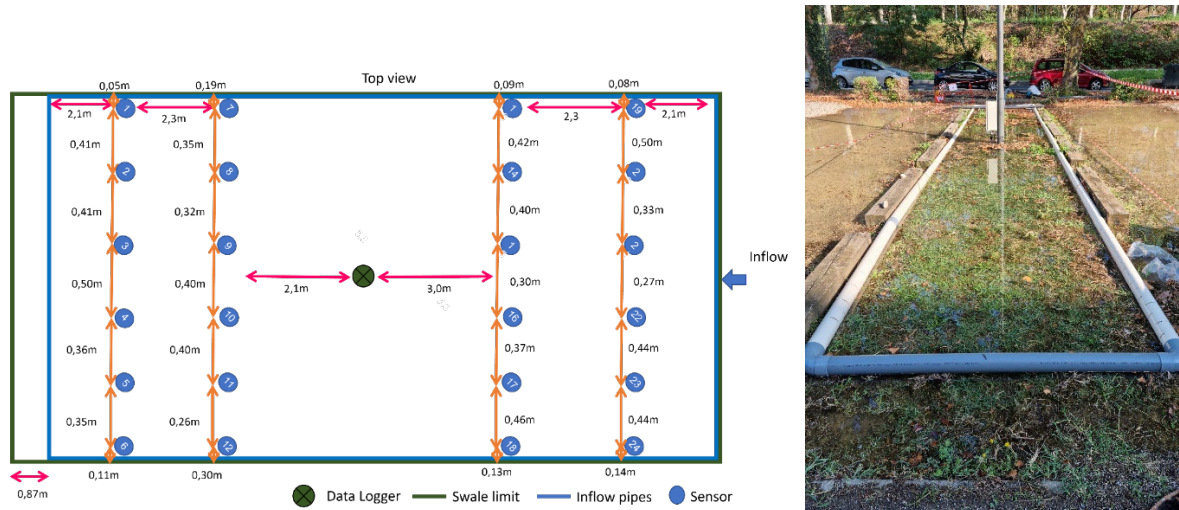


Figure 1: Sketch and picture of the test facility.

3 RESULTS

The expected results are the evolution of the spatial distribution of soil moisture in the swale and its recovery time after an extreme event. All these data will be used to strengthen models dedicated to the simulation of infiltration processes in SUDS during and after an extreme precipitation event. All results are still being processed and evaluated and will be presented during the conference.

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