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## Évaluation de l'efficacité de traitement in-situ des MES dans un système décentralisé de traitement des eaux pluviales à l'aide d'un suivi en continu

### Evaluation of in-situ TSS removal efficiency of a decentralized stormwater treatment system by means of continuous measurements

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#### RÉSUMÉ

L'objectif de cette étude est d'évaluer l'efficacité d'un système décentralisé de traitement Sedipipe® pour les MES dans les eaux pluviales, à l'aide de mesures en continu *in-situ* et ainsi de comparer les résultats à l'efficacité de traitement fournie par le fabricant du système. À cette fin, une campagne de surveillance a été menée sur un système Sedipipe® installé à Lausanne, Suisse, avec des mesures en continu de turbidité et débit, pour 169 événements pluvieux sur une période d'une année. Les résultats indiquent que l'efficacité globale de traitement estimée à partir de la surveillance *in-situ* est d'environ 24 %, ce qui est remarquablement inférieur à la valeur fournie par le fabricant (environ 75 %). Aucune tendance particulière dans le temps (p.e. saisonnalité ou tendance décroissante) n'a pu être établie pour les efficacités de traitement événementielles. La remise en suspension locale des sédiments dans le système pourrait se produire principalement lors des événements pluvieux faibles. Cette étude souligne le potentiel des mesures à résolution temporelle fine dans le but de vérifier les performances *in-situ* et mieux comprendre le comportement des systèmes décentralisés de traitement des eaux pluviales.

#### ABSTRACT

The objective of this study is to evaluate the efficiency of a decentralized stormwater treatment system called Sedipipe® for the removal of TSS by means of *in-situ* online measurements and compare the results to the expected removal efficiency reported by the manufacturer of the system. For this purpose, a monitoring campaign of a Sedipipe® system installed in Lausanne, Switzerland was conducted, including continuous turbidity and flow rate measurements for 169 rainfall events over a period of one year. The results indicated that the global removal efficiency estimated from the *in-situ* monitoring is about 24 %, which is remarkably lower when compared to the value provided by the manufacturer (about 75 %). No particular pattern over time (e.g. seasonality or decreasing trend) for the removal efficiencies could be established. Local resuspension of sediments in the system might be principally occurring for smaller rainfall events. Overall, this study stresses the potential of high temporal resolution measurements to verify the *in-situ* performance and better understand the behavior of decentralized stormwater treatment systems.

#### MOTS CLÉS

Green-blue infrastructure, online monitoring, pollution management, removal efficiency, stormwater sediments

Efficacité de traitement, gestion de la pollution, infrastructure verte et bleue, suivi en continu, sédiments des eaux pluviales

## 1 INTRODUCTION

Urban runoff pollutants have been reported to transport high loads of different type of pollutants, including high concentrations and loads of Total Suspended Solids (TSS) and heavy metals (e.g. Zn, Cu and Pb). These pollutants are principally originated from different sources such as vehicle brake emissions, tire wear, roof covering materials and atmospheric deposition (Müller et al., 2020).

Within the last three decades, a stock of technical solutions has been developed aimed to treat urban runoff throughout decentralized systems (i.e. systems that ensure treatment close to the pollution sources). Indeed, decentralized approaches might provide an efficient way to reduce stormwater pollutants emissions to the receiving water bodies. However, the long-term removal efficiency of pollutants for this type of systems when installed *in-situ* is rarely contrasted to the performance reported by manufacturers (principally from laboratory-controlled conditions). This long-term evaluation of stormwater treatment capacity can be evaluated *in-situ* by means of online monitoring (e.g. Uv-Vis spectrometers or turbidimeters) (Lepot et al., 2016).

The aim of this study is to highlight the potential of long-term online monitoring as a tool for assessing TSS removal efficiency of decentralized systems and comparing these results to the values reported by manufacturers, which are generally obtained from laboratory and/or controlled settings. This study was carried out in a decentralized system called Sedipipe®, a settling-based treatment systems that remains a popular option in the Swiss and European context.

## 2 MATERIALS AND METHODS

### 2.1 Experimental site

The studied Sedipipe® system is installed under the Avenue de Rhodanie roundabout in Lausanne, Switzerland. The Sedipipe® treatment system consists of a 12 m long, large-diameter (0.6 m) pipe with a slight slope, where the water velocity is lowered with a counter slope, allowing the suspended solids to be settled. The analyzed system collects stormwater with a pollution level considered as high (according to Swiss local regulations), collecting stormwater from a road catchment of about 4'000 m<sup>2</sup>.

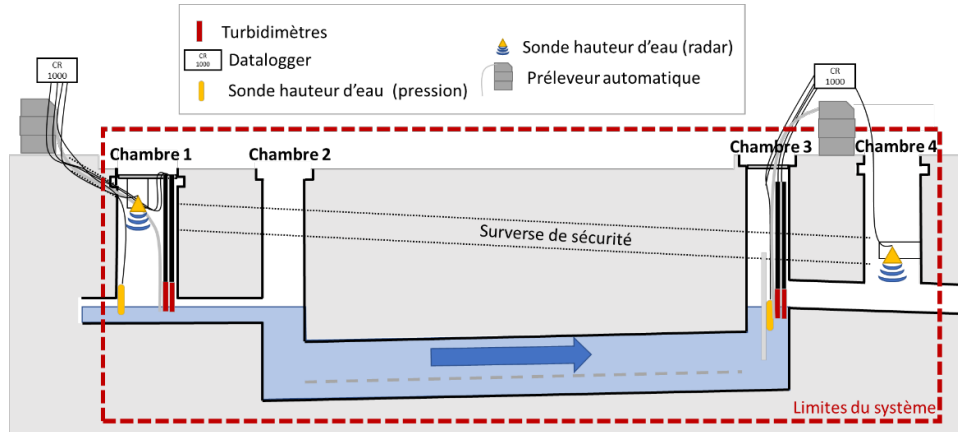


Figure 1. the studied Sedipipe® system and installed monitoring system

### 2.2 Data processing

The *in-situ* evaluation of pollutants removal capacity of the Sedipipe® was performed by employing data from different sensors installed at the inlet and outlet of the system (Figure 1). Water depths and turbidity time series for 169 rainfall events were recorded during 12 months (June 2021 to August 2022), including a time-step of one-minute ( $\Delta t = 1 \text{ min}$ ). The data processing included the estimation of calibration functions to transform the water depth and turbidity signals into time series of flow rate  $Q$  [L/s] and Total Suspended Solids Concentrations (TSS<sub>c</sub>) [mg/L]. To obtain the  $Q$  time series, different flowrate values were induced into the system under controlled conditions, measuring the corresponding water depths at the inlet. It was also verified that the  $Q_{\text{inlet}} = Q_{\text{outlet}}$ , as no storage in the system occurs. In addition, stormwater elemental samples were collected from different rainfall events by two automated 24 bottles samplers at the inlet and outlet. These samples were employed for estimating calibration functions to transform the turbidity signals into TSS<sub>c</sub> time series as shown in Figure 2, according to the methods proposed in Sandoval et al. (2021).

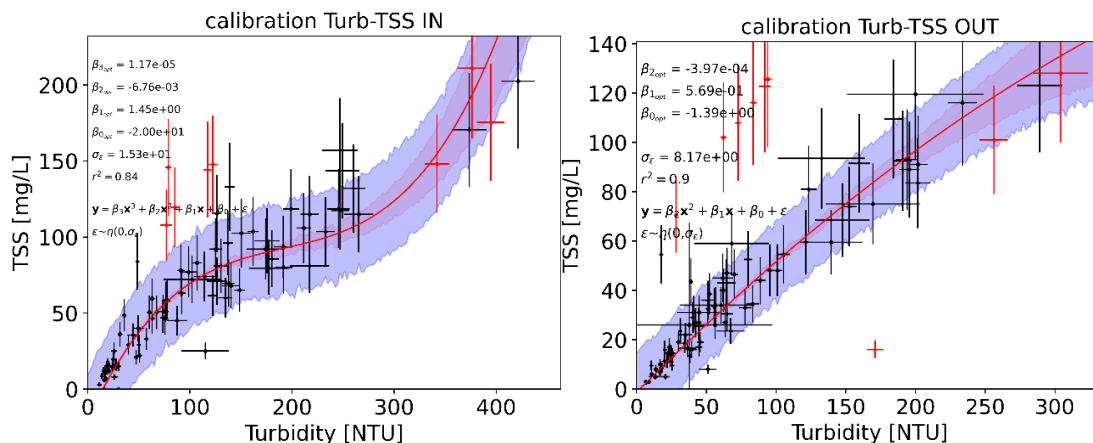


Figure 2. transformation functions of turbidity signals into TSS concentrations

The pollutants load time series at the inlet and outlet were calculated from the  $TSS_c$  [mg/L] and  $Q$  [L/s] time series as  $TSS_{load\_inlet} = TSS_{c\_inlet} \cdot Q$  and  $TSS_{load\_outlet} = TSS_{c\_outlet} \cdot Q$ , respectively. Figure 3 shows the results for a particular rainfall event, including the 95 % coverage intervals of the measurements (shaded bands).

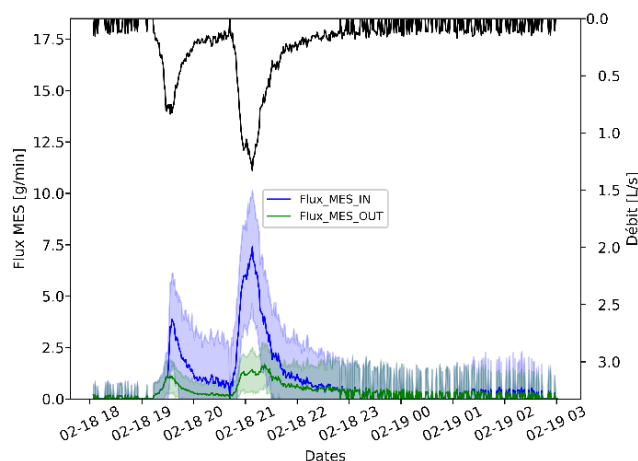


Figure 3.  $TSS_{load\_inlet}$  (blue) and  $TSS_{load\_outlet}$  (green) compared to the flow rate  $Q$  at the inlet (black) for a rainfall event

### 2.3 Removal efficiency calculation

The *in-situ* TSS removal efficiency of the system is estimated from the  $TSS_{load\_inlet}$  and  $TSS_{load\_outlet}$  data, as presented in Eq 1.

$$\eta = 1 - \frac{\sum_{i=1}^n TSS_{load\_outlet} \cdot \Delta t}{\sum_{i=1}^n TSS_{load\_inlet} \cdot \Delta t} \quad \text{Eq 1}$$

where  $n$  is the total of measurements and  $\eta$  is the removal efficiency. Two types of TSS removal efficiency were assessed for this study case:  $\eta_{global}$  referring to the global removal efficiency, calculated with the totality of the rainfall events and  $\eta_{ev}$  referring to the removal efficiency for a particular rainfall event.

The manufacturer proposes a curve to calculate the removal efficiency of the Sedipipe® system according to the surface of the catchment. From this information, the system was dimensioned to treat stormwater from a 4,000m<sup>2</sup> catchment, where a 75 % removal of the TSS load is expected.

## 3 RESULTS AND CONCLUSIONS

The results are shown in Figure 4, where: a) the total TSS mass measured at the input and output of the system with the value of  $\eta_{global}$ , b) the TSS mass at the inlet and the outlet for different rainfall events and c) the  $\eta_{ev}$  value for different rainfall events as a function of the total runoff volume, i.e.  $\sum Q \cdot \Delta t$ .

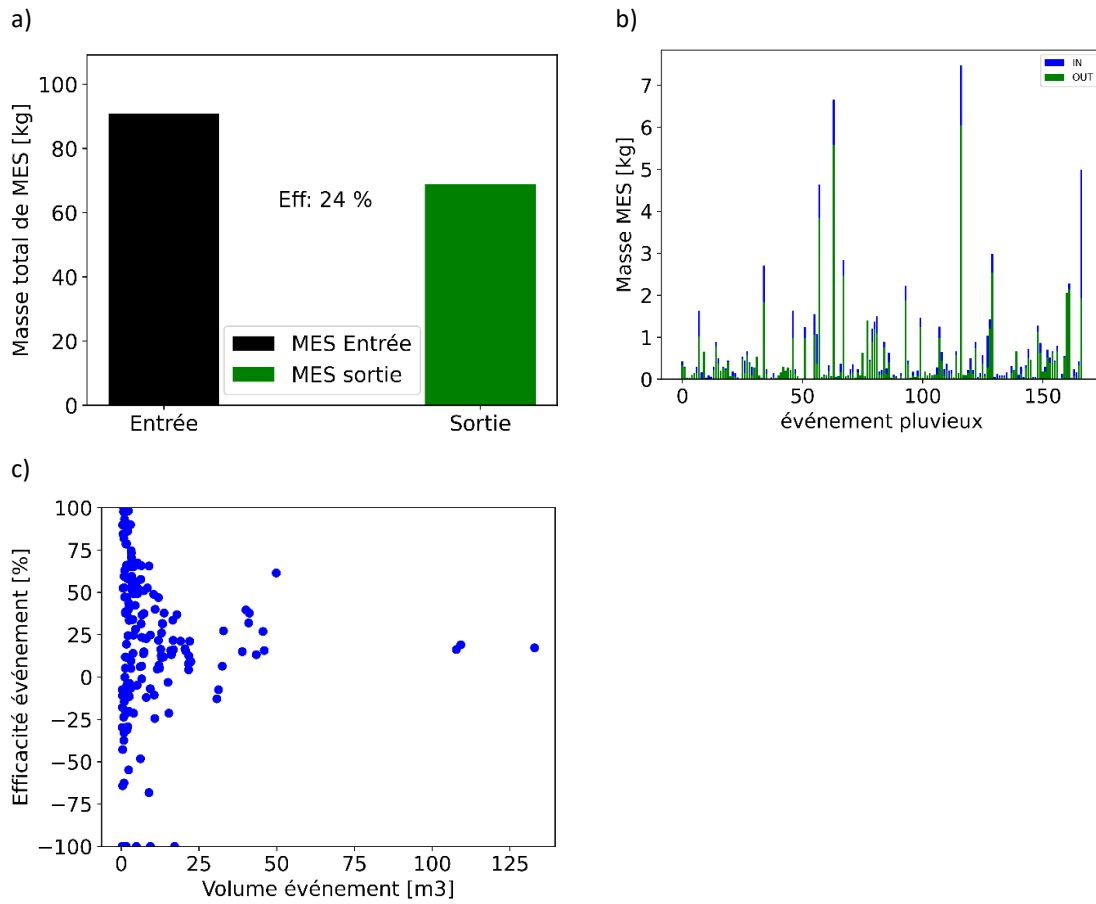


Figure 4. a) TSS total mass at the input and output, b) TSS mass at the inlet and the outlet for different rainfall events and c) The removal efficiency as a function of the event total runoff volume

From the obtained results the following generalities can be observed:

- the  $\eta_{global}$  removal efficiency estimated from the *in-situ* online measurements is about 24 %, which is remarkably lower when compared to the expected value provided by the manufacturer's guide of about 75 %. This value was obtained from laboratory tests under fully controlled settings (see e.g. Schütz et al., 2013 for the same system).
- There is not a particular pattern for the event-based removal efficiencies  $\eta_{ev}$  along the monitoring campaign (no seasonal effect, no linkage with the Antecedent Dry Weather Periods and no temporal trends).
- A higher variability for the  $\eta_{ev}$  values is reported for smaller rainfall events (e.g. total runoff volumes above 25 m<sup>3</sup>), including negative  $\eta_{ev}$  values, suggesting that e.g. local resuspension inside the system might be principally occurring for smaller events. On the other hand, the  $\eta_{ev}$  values reported for larger events (e.g. total runoff volumes above 25 m<sup>3</sup>) remained close to the  $\eta_{global}$  value (i.e. 24 %). Overall, this study stresses the potential of high temporal resolution measurements of TSS to verify the *in-situ* performance and better understand the behavior of decentralized stormwater treatment systems.

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