Assessing the Performance of Decentralised Stormwater Management Measures by means of Continuous Turbidity Measurements

Mesures continues de turbidité pour évaluer la performance des mesures décentralisées de gestion des eaux pluviales

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RÉSUMÉ

La performance in situ des grands systèmes décentralisés de traitement des eaux pluviales est étudiée au moyen de mesures continues de la turbidité. Les mesures de turbidité sont utilisées comme substitut pour estimer les concentrations continues de solides totaux en suspension (TSS). Les charges événementielles des TSS sont calculées à l'entrée et à la sortie de deux systèmes de traitement des eaux pluviales, qui sont tous deux installés à la sortie d'un bassin versant présentant un potentiel de pollution élevé. La performance spécifique à l'événement est définie comme le rapport entre les charges TSS en entrée et en sortie. D'après les données de mesure obtenues, le rendement global de la charge TSS est d'environ 32 %.

ABSTRACT

The in-situ performance of large decentralised stormwater treatment systems is investigated by means of continuous turbidity measurements. Turbidity measurements are used as a surrogate to continuously estimate Total Suspended Solid (TSS) concentrations. TSS event loads are calculated at the inlet and outlet of two stormwater treatment systems, which both are installed at the outlet of catchments with high pollution potential. The event-specific performance is defined as ratio between TSS loads of inflow and outflow. Based on measurement data obtained, the overall TSS load retention efficiency is about 32 %.

KEYWORDS

Decentralized systems, Continuous turbidity measurements, Measurement data management, Stormwater management, TSS, SUDS

1 INTRODUCTION

Stormwater runoff from urban areas is considered as a major nonpoint source of pollutants affecting the quality of the receiving water (Allen Burton & Pitt, 2001). The need for treatment of urban stormwater runoff in the state of North Rhine-Westphalia (NRW), Germany is regulated by an official decree (MKULNV NRW, 2004). Herein, according to the area of origin, stormwater runoff is divided into the categories I (unpolluted), II (slightly polluted) and III (heavily polluted). Currently, heavily polluted discharges (category III) have to be treated at a waste water treatment plant (WWTP) or a retention soil filter (RSF). However, limited inflow capacities of the WWTP and the lack of area for RSF in urban areas raise the need for decentralized stormwater management strategies.

Large decentralised, technical treatment systems could be an alternative if their treatment performance is comparable to conventional techniques. In an ongoing research project entitled "Efficiency of large decentralised stormwater treatment systems under real operating conditions (DezNWBA)", large decentralised stormwater treatment systems are currently being investigated at locations with heavily polluted stormwater runoff. By means of continuous quality measurements and parallel sampling (Leutnant et al., 2016), event and long-term efficiencies are determined and the in-situ behaviour of different systems is investigated (Leutnant et al., 2018). This contribution presents the research project and reports on initial results.

2 MATERIALS AND METHODS

2.1 Experimental sites and treatment systems

The experimental site "Am Stadtgraben" (2.3 ha impervious area) is located in the centre of Münster, Germany. A high traffic road (1.4 ha impervious area) with approx. 30,000 cars/24h dominates the land-use. Stormwater is treated by a SediPipe XL 600/12 (Fränkische Rohrwerke). In case of an event, stormwater is pumped from a separated sewer with up to 6.1 l/s by means of a peristaltic pump. Solids are supposed to be restrained through sedimentation. A flow separator in the vicinity of the bottom aims to prevent remobilisation of particles. An immersion tube in front of the outlet serves to retain floating matter and light liquids.

The site "Mecklenbecker Straße" (5 ha impervious area) consists mainly of detached houses and two main roads. Main pollutant sources are the high traffic roads "Mecklenbecker Straße" (13,000 cars/24h) and "Boeselagerstraße" (9,000 cars/24h) with 1 ha impervious area. Here, a lamella clarifier of type ViaTub (Mall) is installed at the catchment’s outlet. The inlet and outlet shafts of the reinforced concrete round tank with an inner diameter of 3 m are divided by a wall with integrated lamellas. Slats are designed to increase the effective area of sedimentation. In the inlet, an immersed pipe intends to reduce turbulence of inflow. Floating materials are retained because the outlet pipe is submerged.

2.2 Measurement data management and processing

Parameters turbidity, pH and electrical conductivity are continuously measured in the inlet and outlet of both systems by means of online probes (VisoTurbIQ700, SensoLyt700IQ, TetraCon700IQ, all WTW). Water level and flow measurements in the sewers control automatic sampling (ASP station, Endress+Hauser). Samples are used to analyse Total Supended Solids (TSS), fraction of total suspended solids below 63µm (TSS63), heavy metals (Cu, Zn) and hydrocarbons.

Measurement data and results of laboratory analysis are automatically processed using the measurement data management system OSCAR (Leutnant et al., 2015). Time series data are stored with open source components (InfluxData, 2017) and visualized via a web interface (Grafana Labs, 2017). Data processing and analysis is performed using the scripting language R (R Core Team, 2018). Processing steps are i) verification, ii) correction, iii) transformation (e.g. turbidity to TSS, cf. Métadier & Bertrand-Krajewski (2012)), iv) event selection, v) calculation of event parameters (sum of precipitation, runoff volume, TSS event loads, TSS event mean concentration (EMC)). In the course of data analysis, event characteristics are aggregated and statistically evaluated.

3 RESULTS

The in-situ performance of large decentralised systems is determined with continuous turbidity time series. Monitoring data of the two commercially available systems of type SediPipe XL 600/12 (Fränkische Rohrwerke) and lamella clarifier ViaTub 18R 63 (Mall) are available since December 2017. Figure 1 shows an example of the installation of a quality measurement unit at site "Am Stadtgraben".

The event-specific performance is qualified on the basis of continuous turbidity signals (Figure 2). At site “Am Stadtgraben”, 11 events were completely analysed until now. The correlation between TSS and turbidity was found to be linear at both inflow and outflow (correlation coefficient R^2 = 0.73 and R^2 = 0.68). Observed TSS loads at the inflow range from 4 kg and 35 kg, at the outflow TSS loads from 2.6 kg to 26 kg were measured. The highest retention efficiency was 67 %, the smallest 12 %. The overall efficiency, which is calculated as ratio from the sum of the inflow and outflow loads of all events is 32 %. Results for the ViaTub system are expected to be available in January 2019.

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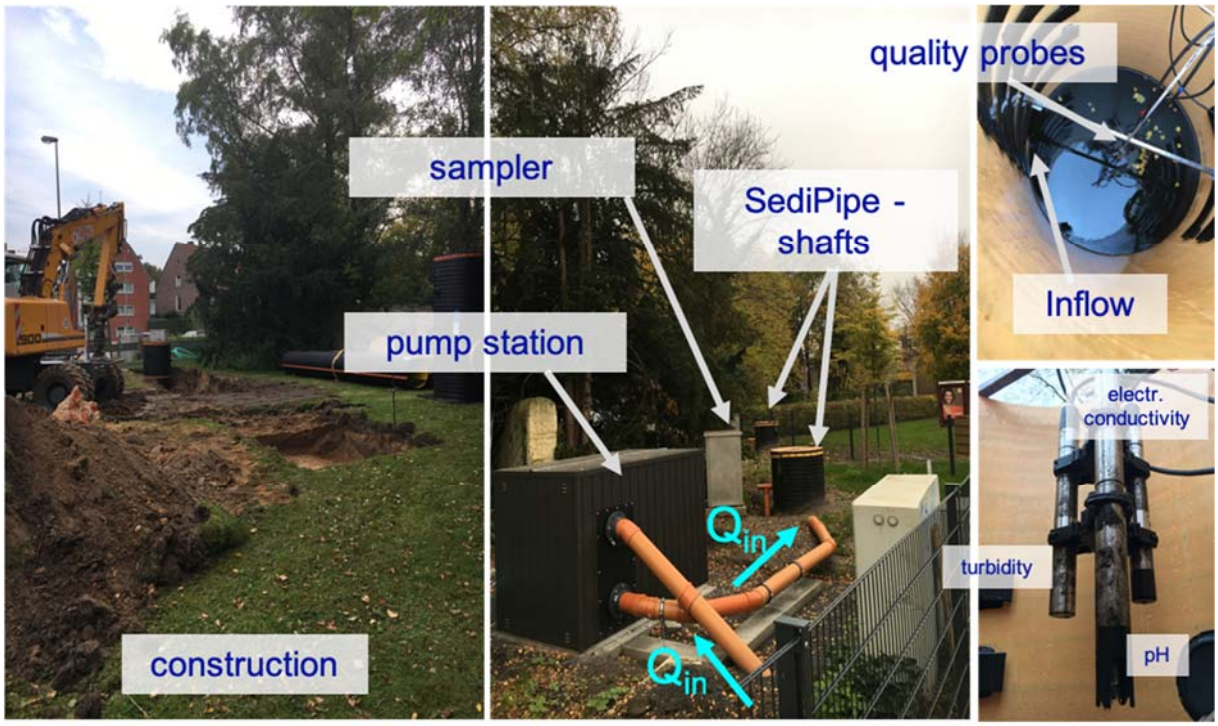

Figure 1: Monitoring station "Am Stadtgraben" (left: construction site, center: pump station, SediPipe-shafts and sampler; top right: Arrangement of the quality probes in the starting shaft; bottom right: Quality measuring unit after first event)

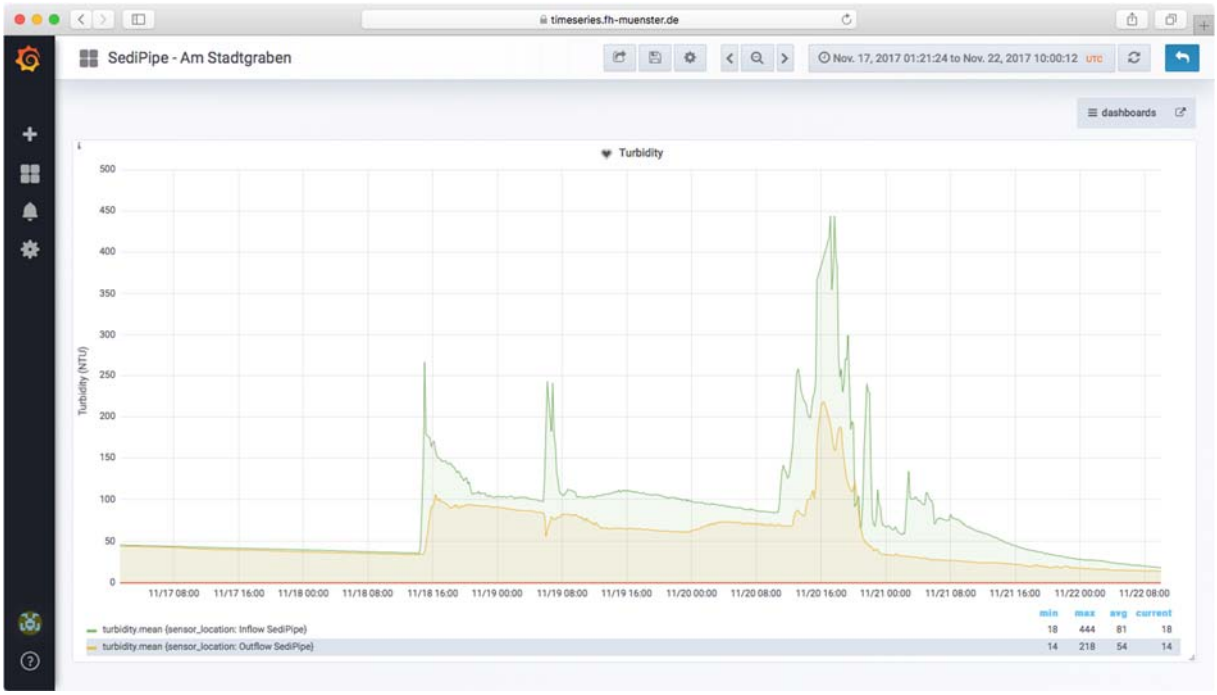

Figure 2: Web-based visualization of measurement data of site "Am Stadtgraben" (green: turbidity signal at the inflow; orange: turbidity signal at the outflow)