Survey of the Operational Status of Twenty Biofilter Practices in Sweden

Enquête sur le statut opérationnel de vingt ouvrages d'infiltration végétalisés en Suède

Alisha Goldstein[1]; Ahmed Mohammed Al-Rubaei[2]; Godecke-Tobias Blecken[3]; Maria Viklander[4]; William F. Hunt III[5]

[1]Dept. of Biological and Agriculture Engineering, North Carolina State Univ., Campus Box 7625, Raleigh, NC 27695. E-mail: aegolds2@ncsu.edu
[2]PhD, Dept. of Civil, Environmental, and Natural Resources Engineering, Luleå Univ. of Technology, 97187 Luleå, Sweden. E-mail: ahmed@ltu.se; Dept. of Building and Construction Engineering, Univ. of Technology, Baghdad, Iraq
[3]Associate Professor, Dept. of Civil,Environmental, and Natural Resources Engineering, Luleå Univ. of Technology, 97187 Luleå, Sweden. E-mail: godble@ltu.se
[4]Professor, , Dept. of Civil, Environmental, and Natural Resources Engineering, Luleå Univ. of Technology, 97187 Luleå, Sweden. E-mail: marvik@ltu.se
[5]William Neal Reynolds Professor and Extension Specialist, Dept. of Biological and Agriculture Engineering, North Carolina State Univ., Campus Box 7625, Raleigh, NC 27695. E-mail: wfhunt@ncsu.edu

RÉSUMÉ

Cette étude évalue l'état de fonctionnement de vingt bassins de rétention dans neuf villes de Suède en ce qui concerne le stockage disponible dans le biofiltre, la composition du sol et le taux d'infiltration. Ces indicateurs établissent la capacité de rétention volumétrique d'eau de chaque installation. Enfin, nous avons examiné si les installations de biofiltre ont le potentiel d'atteindre les objectifs fixés par les municipalités en charge et si elles sont correctement entretenues. Les résultats préliminaires indiquent que les constituants du sol sont tous comparables aux recommandations des pourcentages de sable et de fines matières organiques des installations utilisées dans les municipalités américaines. La conductivité hydraulique des biofiltres testés varie de 30 à 962 mm/h. Cette variation de taux indique que tous les sites ne fonctionnent pas de manière optimale. Une analyse supplémentaire sera entreprise pour examiner les biofiltres en relation avec leurs critères de conception, leur état de fonctionnement ainsi que le contexte physique du site.

ABSTRACT

This study evaluates the operational status of twenty biofilter facilities across 9 cities in Sweden with respect to the available storage in the biofilter, the soil media composition, and the infiltration rate. These indicators establish the water volumetric retention capacity of each biofilter practice. Finally, we investigated if the biofilter facilities have the potential to meet the objectives set by the operating municipalities and are being properly maintained. Preliminary results indicate that the soil media were all consistent with respect to percent sand, fines, and organic matter and comparable to design recommendations used by U.S. municipalities. The field-tested hydraulic conductivity for the biofilters ranged from 30-962 mm/hr. This range of values indicate that not all the sites are performing optimally. Additional analysis will be undertaken to examine the biofilters in relationship to its design criteria, operational status, and the physical context of the site.

KEYWORDS

Bioretention, maintenance, stormwater control measures (SCM), urban stormwater management, infiltration

1 INTRODUCTION

Rapid urbanization has led to an increase of impervious surfaces which has resulted in larger volumes of stormwater runoff to nearby aquatic waterbodies. Frequently, this runoff by virtue of transporting any particle in its path accumulates sediments, heavy metals, and organic matter. These pollutants can impair a waterbody by elevating levels of certain nutrients that interrupt biological processes (Walsh, 2000). On-site stormwater control measures (SCMs) have been developed to capture urban stormwater at its source and treat it before the stormwater enters a waterbody (Fletcher et al., 2015). A common practice in developed areas is biofilters distinguished by a depressed landscaped filter bed which has a mixture of sand, soil, and organic matter. The soil composition is critical for capturing runoff, filtering pollutants, and supporting vegetation. When designed and implemented according to plan(s), biofilters can achieve a number of objectives including water quality treatment, retention, groundwater recharge, aesthetic enhancement, and traffic calming (Asleson et al., 2009; Wardynski et al., 2012; Blecken, et al., 2017). Despite all these benefits, biofilters cannot work efficiently if they are not inspected and maintained regularly (Blecken, et al., 2017). Visual inspections of biofilters structures should be carried out frequently and after major storm events (Hunt et al. 2015). However, little research has been done on the inspection, maintenance regimes, and investigation of existing biofilter facilities (Blecken, et al., 2017). There is a growing need to evaluate the functionality and maintenance needs of established biofilters facilities to understand their long-term performance and their impacts on water recipients as well as the factors affecting their performance (D'Arcy and Sieker 2015; Al-Rubaei, 2016; Blecken, et al., 2017).

This study evaluates the operational status of twenty biofilters facilities across Sweden with respect to the available storage in the biofilter, the soil media composition, and the infiltration rate. These indicators establish the water volumetric retention capacity of each bioretention practice. Finally, we investigated if the biofilter facilities have the potential to meet the objectives set by the operating municipalities and are being properly maintained.

2 MATERIALS AND METHODS

2.1 Biofilter Sites

The twenty municipal stormwater biofilters are located in the Swedish cities of Vellinge, Malmö, Lund, Munka-Ljungby, Gothenburg, Örebro, Tyresö, Uppsala, and Stockholm. They were sampled between 2 months and 6 years after construction. All of the biofilters have a catchment area that can be characterized as 100% impervious. The source of runoff are roofs, roads, sidewalks, and parking lots. The key characteristics of the biofilters and their eff volumes are shown in Table 1.

Table 1. Characteristics of the biofilters (

Site Number	Approximate Storage Volume (m3)	Designed Biofilter Area (m2)	Catchment Area (m2)	Year of Construction	Age at Sampling	Runoff Conveyance
1	48	165	1900	Jul-2009	7 months	Curb Cuts
2	179	650	3000	2015	3 years	Curb Cuts
3	47	160	4500	May-2018	2 months	Sheet Flow
4	8		230	2016	2 years	Distribution Gutter
5	8		230	2016	2 years	Distribution Gutter
6	9.5	30		2016	2 years	Downspout
7	10	26		2016	2 years	Downspout
8	22					Sheet Flow
9	70	200	5000	2017	1 year	Sheet Flow
10	2025	700		2015	3 years	Sheet Flow
11		208		2017	2 years	Sheet Flow
12	12	36	360	2016	2 years	Curb Cuts
13	4.5	15	1900	2012	6 years	Curb Cuts
14	3.3	11	1800	2012	6 years	Curb Cuts
15				2013		Inlet and Outlet
16				2013	5 years	Sheet Flow
17						Curb Cuts
18	22	117		2016	2 years	Curb Cuts
19				2017	1 year	Curb Cuts
20				2017	1 year	Curb Cuts

Note: Information is still being collected about some of the sites.

The site data presented herein was provided by the corresponding operator municipality. Unfortunately, the municipal records was incomplete. Information is still being collected about the sites or will be determined from other sources. Additionally, an inspection and maintenance checklist was used to determine the facility's general status.

2.2 Sediment Sampling and Analyses

In June 2018, sediment samples from the biofilters were collected. For spatial comparison, the samples were collected from three sampling locations (i.e. inlet, outlet, and along the flowpath) in each biofilter using either an auger or shovel depending on the compaction of the media. The samples collected were put into plastic bags and stored in a portable box until they were transported to an accredited laboratory for analysis. The media samples were analyzed for particle size distribution (PSD) and organic media content. For all samples, dry sieving was carried out using standardized sieves in accordance with ISO 3310-1 following the ASTM D422 - 63 standard test methods (ASTM, 2007). Sub-samples were analyzed for loss on ignition (LOI) according to the standard method SS 28113 (SIS, 1981).

2.3 Infiltration Capacity Measurements

At each biofilter, the infiltration capacity measurements were carried out at three sampling locations (inlet, outlet, and flowpoint) using Modified Philip-Dunne (MPD) infiltrometers. This method follows the ASTM standard procedure D8152 – 18 (ASTM, 2018), as recommended by the manufacturer of the MPD infiltrometer (Upstream Technologies MPD Infiltrometer).

3 RESULTS AND DISCUSSION

Preliminary analysis indicates that the soil media for the various biofilters were comparable to each other while the infiltration results indicated a range of performance. The soil media on average had a composition of 10-16% gravel, 74-81% sand, and 4-7% silt (see Figure 1 for site sample composition) The organic matter content was between 4-7%.

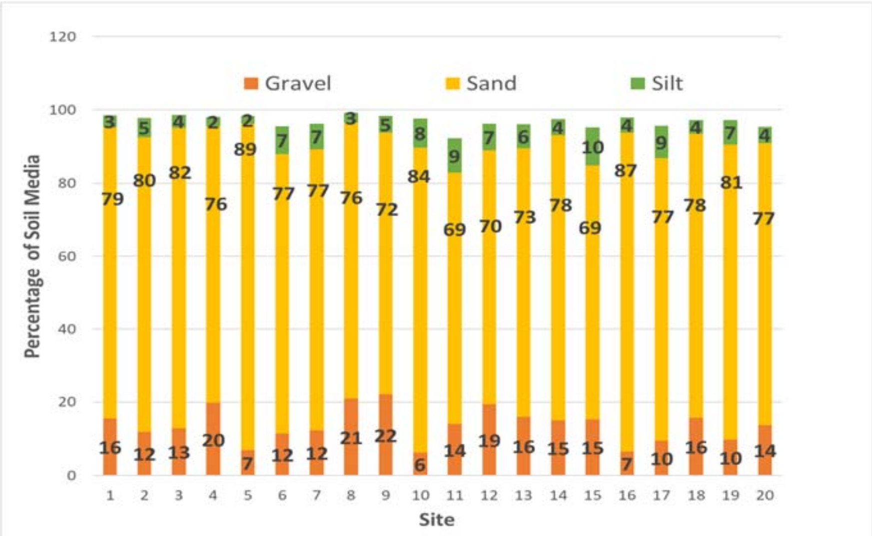

Figure 1. Composition of Media from Sampled Biolfilters

The composition of the soil media is important for maintaining long-term permeability and provide favorable conditions for vegetation to thrive. The soil media evaluated is comparable to the prevailing design recommendations in various city or states in USA (see Table 2) with the exception of the observed gravel content.

Table 2. Comparison of Soil Media Assessed in Sweden to U.S. Soil Media Recommendations

	Sweden	DC	Minnesota	NC
Gravel (>4mm)	10-16%			
Sand (>0.125mm and <4mm)	74-81%	80-90%	60-70%	75-85%
Silt (<0.125mm)	4-7%	10-20%	15-25%	8-10%
Organic Matter	4-7%	3-5%	15-25%	5-10%

The average hydraulic conductivity assessed in the field at each site ranges from 30-962 mm/hr (see Figure 2).

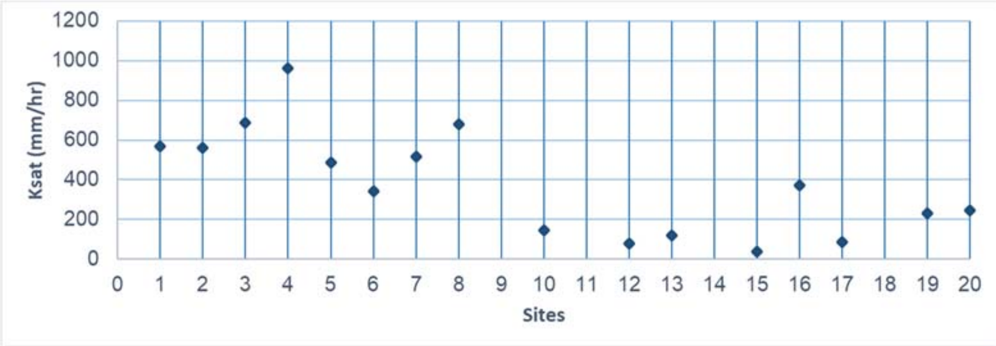

Figure 2. Average Hydraulic Conductivity at each Biofilter Site

This broad range indicate that even with similar soil media, the permeability is not consistent. Other parameters such as the hydraulic loading rate, sediment load, and maintenance activities need to be evaluated to determine what other attribute factors may be the limiting factor for the performance of each biofilter. Several minor issues were observed during the visual inspection, mainly due to sediment and litter accumulation at their inflow and outflow points. However, most of the evaluated biofilters were in relatively good conditions. More detailed analysis and discussion of the results will be undertaken to be ready for Novatech 2019.

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