IWA 17th SWWS AND 9th ROS
10th–14th November, 2024
Curitiba-Brazil

One Year Field Study of Northern European Constructed Wetlands for Nutrient Removal in Greywater

One year field study of 5 European constructed wetlands for treatment of urban greywater

Hall, A.*,**, Davidsson, Å.** and Kjerstadius, H.***

*Sweden Water Research, Ideon Science Park Scheelevägen 15 SE-223 70 Lund, Sweden

**Division of Chemical Engineering, Department of Process and Life Science Engineering, Lund University, Box 124, SE-22100 Lund, Sweden

***Nordvästra Skånes Vatten och Avlopp, Box 2022 SE-25002 Helsingborg, Sweden

Highlights:

- One year field study of urban constructed wetlands in Sweden, Norway and the Netherlands.
- Constructed Wetlands can meet the requirements set out in the EU Urban Wastewater Treatment Directive.
- Constructed wetlands are better suited to treat greywater than mixed wastewater.
- Wetland age does not seem to correlate with effectiveness of treatment.

Keywords: Nature Based Solutions; Wetlands; Greywater

INTRODUCTION

Constructed wetlands have been a long-used strategy to treat source separated greywater (Arden & Ma, 2018; Boano et al., 2020; Pradhan et al., 2019). Their benefits include low input, low energy demand, and low maintenance costs. With new requirements for carbon neutrality on the horizon in Europe, constructed wetlands offer an attractive and simple solution to meet that goal. However, it is unclear if constructed wetlands will be capable of meeting future effluent water quality standards. This study aims to assess five existing constructed wetlands across northern Europe over the course of a year (8 months at the time of writing) to determine what treatment efficiency and effluent water quality can be expected in the context of nutrient removal.

METHODOLOGY

Five constructed wetlands were selected across Northern Europe: Gyllebo and Toarp in southern Sweden, Klosterenga in Oslo, NO, and Reitdiep and Drielanden in Groningen, NL. All wetlands, with the exception of Toarp, treat source separated greywater and do not receive contributions from rainfall runoff, though rainfall over the surface of the wetland does infiltrate. All wetlands except Gyllebo are also open to the air and therefore affected by evapotranspiration. Toarp treats mixed domestic wastewater but was originally designed to treat only greywater. A description of each wetland is available in Table 1. All wetlands function as horizontal subsurface flow constructed wetlands without recirculation. Samples were taken from each sampling site once a month for a total of one year at the point directly before (settled inf) entering and directly after exiting (eff) the wetland.

Table 1. Wetland Characteristics

Name	Year Built	Density	Average Daily Flow (m3/d)	Bed size and flow path	Substrate
Gyllebo	1976	Rural	18	3000 m2 HSSF	Soil, capped with impervious layer
Toarp (mixed waste water)	1992	Suburb	18	300 m2 HSSF	Soil planted with reeds
Klosterenga	2000	Urban	10	100 m2 dome biofilter + HSSF	Filtralite-P
Drielanden	1990s, renovated 2011	Suburb	40	1000 m2 VSSF -> 2300 m2 HSF -> 3000 m2 HSF	VSSF- washed shells and sand HSF- planted with reed
Reitdiep	2019	Suburb	34	4x 300 m2 VSSF -> 2400 m2 HSSF -> 2400 m2 HSSF	VSSF – washed shells and sand, planted with willow HSSF – lava rock planted with willow

Gyllebo had an additional sampling point where greywater enters the collection tank (raw inf) for the first 4 months. Samples were measured immediately for temperature, pH, conductivity, dissolved oxygen content, and turbidity. Samples were then transported on ice and frozen until analysis of nutrients. After being thawed to room temperature, samples were filtered through 0.45 µm regenerated cellulose syringe filters before being analyzed for chemical oxygen demand (COD), total nitrogen (TN), ammonia (NH4), nitrate (NO3), total phosphorus (TP), and phosphate (PO4) using Hach Lange cuvettes.

RESULTS

As can be seen in Figure 1, there was a wide range of variability in influent concentrations seen at all the wetlands included in this study. Despite high influent variability, effluent COD, TN, and TP concentrations were relatively stable at all wetlands except Toarp. COD concentrations in effluent waters were below 50 mg/L at all filter sites, TN concentrations were below 5 mg/L at all greywater sites except Klosterenga, and TP was below 0.5 mg/L at all greywater sites. Since Toarp was the only site treating mixed wastewater, it is likely that the failure to remove as much nitrogen and phosphorous is a reflection of higher influent concentrations and nutrient loading. When comparing the average removal efficiency of COD, TN, and TP (noted in Figure 1), Toarp performs below the other sites in the removal of COD, TN, and TP. For COD and TN, this difference not very large, though it is very clear for TP. Removal efficiency. Removal efficiency along with residual concentrations indicate that source separated greywater may be better suited to this style of treatment than a mixed wastewater. When comparing the wetlands, there does not seem to be a correlation between functionality and age or size per person equivalent since Gyllebo (50 years old) a similar effluent quality to Klosterenga (30 years old) and Drielanden (13 years old) as well as Reitdiep (4 years old). Again, the only exception to this trend is TP, where Reitdiep performs the best at removing phosphorous by far.

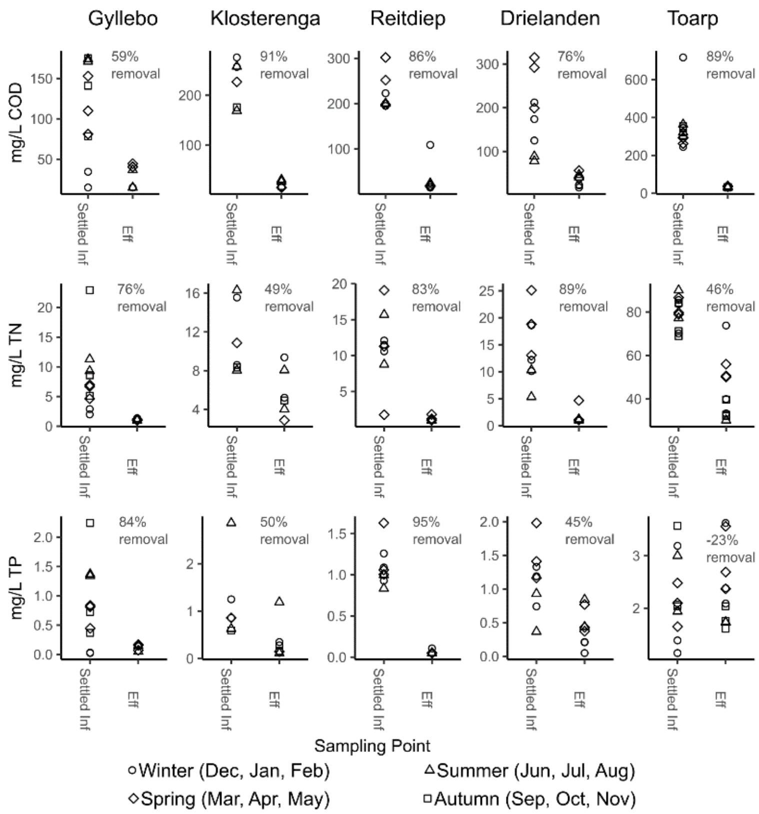

Figure 1. Nutrient Removal across 5 constructed wetlands in Northern Europe with the average removal noted for each site and parameter.

CONCLUSIONS

Based on these results, constructed wetlands can be used to effectively treat greywater within the bounds of the EU Urban Wastewater Treatment Directive ("Proposal for a Directive of the European Parliament and of the Council concerning Urban Wastewater Treatment (recast)," 2022/0345(COD)), which limits effluent COD concentrations to 50 mg/L, TN effluent concentrations to 6 mg/L, and TP effluent concentrations to 0.5 mg/L. Monitoring of these wetlands is ongoing to see if seasonality effects the treatment abilities of these wetlands.

ANKNOWLEDGEMENTS

The authors would like to thank Ignatius Ariffin and the DeSAH team as well as Melesse Eshetu Moges and the ScanWater team for their help in sampling the study sites in the Netherlands and Norway. Thank you to Claes Ericson and Stefan Björk for help sampling the study sites in Sweden and providing historical data from the Swedish sites. Thank you to Groningen Municipality and Fleur Rempe from TAUW for providing historical data for the study sites in the Netherlands.

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