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The French two-stage vertical flow constructed wetland in subarctic climate

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Abstract
Conventional small wastewater treatment plants in Sweden produce a sludge that needs to be collected and transported long distances to a centralised treatment facility. As many of these small plants are old and need replacement, the question arises weather a more sustainable solution is possible. The French two-stage vertical flow constructed wetland (VFCW) is a method where very little sludge handling is required, as the sludge is treated on-site. Therefore, this study aims to investigate cold climate performance of such a system in northern Sweden. A pilot-scale VFCW was built and sampled for BOD, nutrients and microplastics since November 2021. Results indicate that treatment performance is adequate and that microplastic can also be treated.

Keywords
cold climate; adaptions; pilot scale; microplastics

INTRODUCTION

Many small wastewater treatment plants in rural Sweden are old and need replacement. The transportation and treatment of the sewage sludge from these plants are also demanding and costly, both economically and environmentally. The French two-stage vertical flow constructed wetland (VFCW) is a robust and sustainable system to treat rural wastewater in central Europe (Molle et al., 2005). When in operation, the system demands little maintenance and almost no sludge handling. The system has also proven to be successful in mountainous areas with cold temperatures (Prost-Boucle et al., 2015). Therefore, it has the potential to be a robust and sustainable solution for rural wastewater treatment in Sweden. In Northern Sweden, the challenge is the cold and harsh subarctic climate with long winters and short growing seasons. A pilot scale vertical flow wetland was built in a village in the municipality of Luleå, northern Sweden (Fig. 1) with the main aim to test its cold climate treatment performance and to make adaptions during the operation. A secondary aim of this study was to investigate the potential of the 24 months-old pilot wetland to remove microplastics.

METHOD

The construction of the pilot-scale (12 PE) wetland was based on the French two-stage vertical flow constructed wetland, with a sampling tank before, between and after the two treatment stages (tank 1, 2 and 3). The cells were continuously loaded with raw wastewater (1875 L/d) from the adjacent municipal wastewater treatment plant. A sampling campaign was carried out for three consecutive days taking 24h-composite samples from each tank using automatic samplers. In the first tank, the

influent was sampled by taking a sub-sample every time a batch of wastewater was dispatched to the first treatment stage. A tipping bucket was used in tanks 2 and 3 to take flow-proportional samples from the effluents of the first and second stage of the wetland. Samples were analysed for BOD, nitrogen, phosphorus, TOC, DOC, Chloride, microplastics, pH, temperature and TSS.

Figure 1. The two-stage French vertical flow wetland with stage one in background and second stage in the foreground with early stage of reed (*phragmites australis*) establishment in the cells (left); Municipal wastewater treatment plant facility in red building. 24-month-old reed thriving in the cells (right).

RESULTS & CONCLUSION

Preliminary results show that BOD, ammonium, and total phosphorus decreased during treatment (Fig. 2). Thus, the treatment of these compounds was efficient, although the initial concentrations in the influent were very low at the sampling occasion, possibly due to dilution of stormwater entering the municipal sewage system. Nitrate concentrations increased, and total nitrogen was constant, which implies that nitrification occurred in the system, but not denitrification. Preliminary results indicate a reduction of microplastics throughout the treatment stages. Future work includes continuing to assess the cold climate performance, test different methods to prevent winter freezing of the second stage and to investigate the removal of pharmaceuticals.

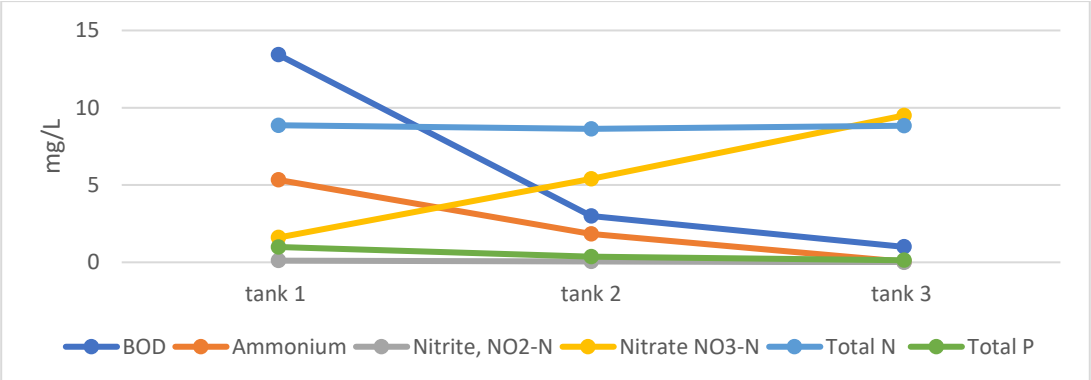

Figure 2. Treatment performance for selected substances throughout the system (tank 1 – tank 3).

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