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Removal of micropollutants in medium-sized WWTP by vertical flow constructed wetlands (VFCWs): performance under laboratory and real conditions

H. Brunhoferova[1*], S. Venditti[1~], J. Hansen[1~].

[1]University of Luxembourg, 6, rue Richard-Coudenhove Kalergi, L-1359 Luxembourg.

[*] hana.brunhoferova@uni.lu
[~] silvia.venditti@uni.lu, joachim.hansen@uni.lu

Abstract: Micropollutants generated in urban agglomerates are commonly found in aquatic environments where they may present a potential danger. Constructed wetlands (CWs) are an attractive alternative for the removal of those compounds from the effluent of medium-sized wastewater treatment plants (WWTPs). To this end, the INTERREG Greater Region-funded project EmiSûre aims to find solutions to mitigate the emission of micropollutants from wastewater facilities. As a part of the project, this study starts with the trial of vertical flow (VF) CWs under lab-scale conditions aiming to select the best substrate. Following steps are designed to optimize the performance of VFCWs in terms of removal of micropollutans under real conditions (i.e. matrix, seasonal changes, temperature) and to derive first approaches for dimensioning. From all the examined substrates, activated biocoal showed the best results in removing macro- and micropollutants and is expected to be the most suitable substrate in long term perspectives.

Keywords: Medium-sized WWTP; Vertical flow wetlands; Micropollutants

Introduction

Over the last fifteen years, researchers have been investigating the occurrence of so-called emerging contaminants, including pharmaceutical compounds in wastewater (Verlicchi and Zambello, 2014). Experience shows that treatment wetlands, although not originally designed for this specific purpose, can remove micropollutants even with higher efficiency than conventional wastewater treatment plants (Matamoros, et. al. 2005 and Dotro, et. al. 2017). Therefore, CWs are used as an additional step after conventional treatment. Among the different wetland configurations, VFCWs showed the highest removal performance for most substances (e. g. Diclofenac), followed by Horizontal Flow wetlands and then Free Water Surface wetlands. In this project, VFCWs, which may be suitable for medium-sized WWTPs, have been investigated as a possible solution for the treatment of municipal wastewater with aim to remove 27 micropollutant compounds.

Material and Methods

The research study is developed in the following three steps (see fig 1):
Step 1: Selection of best sorption material in lab-scale (synthetic wastewater, constant concentrations of contaminants) – TERMINATED. Six identical constructed lysimeters planted with common reeds (Phragmites australis and Iris pseudacorus) are being fed with the synthetic wastewater and have the following substrate composition: Sand 100 % (Column A), Biocoal 30 % and Sand (Column B), Activated Biocoal 15 % and Sand (Column C), Activated Biocoal 30 % and Sand (Column D), Zeolite 15 % and Sand (Column E) and Zeolite 30 % and Sand (Column F). The aim of the lab-scale test was to choose the best soil material in terms of micropollutants' removal from synthetic wastewater.

Step 2: Selection of best sorption material under real conditions (intermediate up-scale test, real wastewater, fluctuating concentrations of contaminants) – TERMINATED. The 3 most promising substrates from Step 1 were chosen and validated with real wastewater within an intermediate up-scale WWTP-4300 PE test at real conditions. These wetlands are being operated under similar conditions as the lab-scale wetlands.
Step 3: Operation of a VF wetland under real conditions (full-scale test, real wastewater, fluctuating concentrations of contaminants) ONGOING. The selected substrate from Step 2 will be tested in full-scale conditions at WWTP-20000 PE. Two identical containers each with same substrate will be operated in an alternate mode for an observation time of 9 months, which will allow to validate the effect of the matrix tested during Step 2, the effect of temperature and weather conditions, varying resting time between feedings and maximum hydraulic load.
Influent and effluent 24 hrs composite samples are being taken regularly for the analysis of macro- and micropollutants' content (test cuvettes and HPLC-MS/MS respectively).

Results and Conclusions

In step 1, 22 out of 27 substances were removed with very high efficiency (> 90 %), with biocoal showing the worst performance of all substrates. Overall zeolite- and activated biocoal-based substrates showed best results and were thus selected at their lower composition (15 %) for Step 2. Eventhough during Step 2 some of the compounds were under the detection limit, activated biocoal substrate resulted as the best suitable candidate for Step 3 (WWTP-20000 PE).

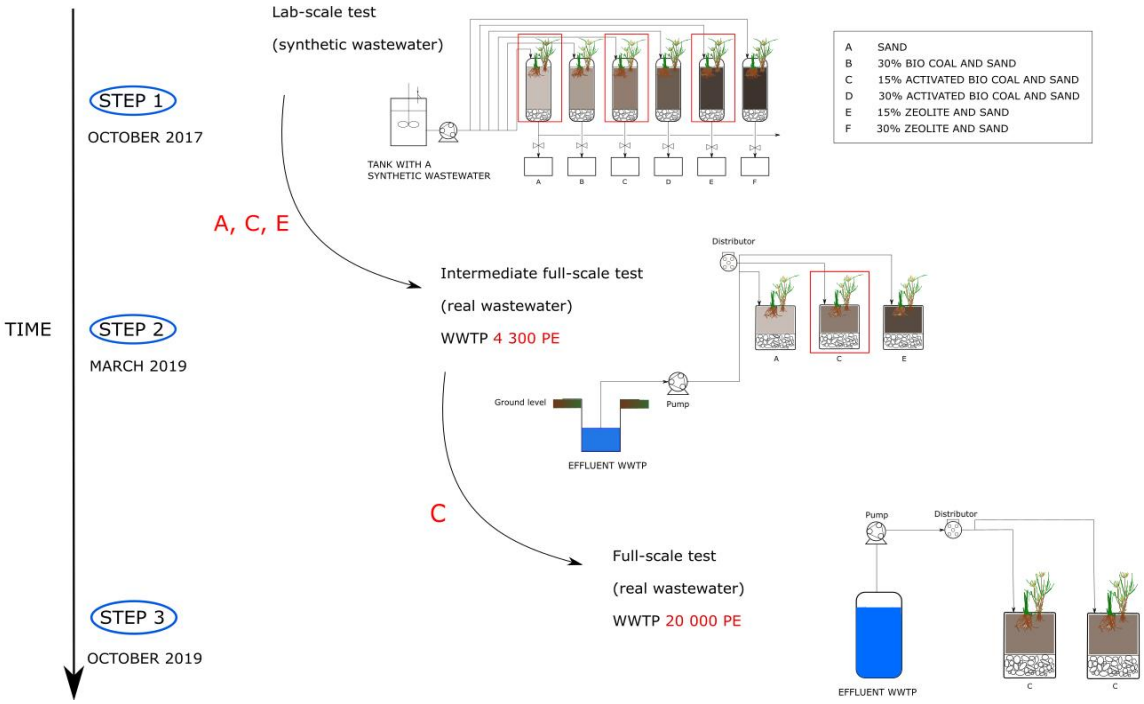

Figure 1.1 EmiSure: approach and results

References

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