# Modelling investigation of HF CW response to sudden and sustained organic and hydraulic overloads

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## INTRODUCTION

Constructed wetlands (CWs) are typically designed assuming idealized steady-state influent loads. However, CWs might face sporadic periods of overloading during their lifespan, due to an increase either in the volume of wastewater to treat or in the pollutant concentrations in wastewater (or both). Although this technology is well known for its buffering capacity, the mechanisms behind it are not well understood. In this study we aim to improve the understanding of the internal processes that make horizontal flow constructed wetlands (HF CWs) able to cope with sudden contaminant and/or hydraulic overloads, and also to investigate if and how sustained overloading affects the long-term performance of these systems.

## METHODS

In this study, we employ the BIO_PORE model (Samsó and García, 2013a), which simulates the hydraulics (Darcian flow), biochemistry (CWM1 biokinetic model, Langergraber et al., 2009), plant effects (nutrient uptake and oxygen release) and the interactions between bacteria and accumulated solids in HF CWs.

The effect of organic overloads is studied using the same HF CW configuration and influent pollutant loads as those considered by Samsó and García (2013b) (10.3 m long and 5.3 m wide CW – COD and TN effluent concentrations validated by Samsó and García (2013a)). The final state of the simulation carried out by Samsó and García (2013b), which corresponds to the end of the 3rd year of operation of the wetland, is used as initial condition of the simulations developed in this work, which are one year long and reproduce the functioning of the HF CW subject to overloads. These overloads are simulated by increasing inflow COD concentrations, hydraulic loads, or both at the same time.

For the increases in organic loads, three overloading scenarios are tested: +10%, +30% and +50% of influent COD concentration while keeping influent $N\text{-}NH_4$ concentrations constant. Additionally, the effect of the HRT is tested by comparing simulations with +30% increase in the organic load, +30% increase in the hydraulic load, and combined +15% increase in both hydraulic and organic loads.

## RESULTS AND DISCUSSION

Both the increase in influent COD concentration and different HRT promote a change in bacterial community distribution, which exhibits the same zonation shown by Samsó and García (2013b), but with differences in the relative amount of biomass of each bacterial group with respect to the total biomass. Comparison of simulations with similar total biomass reveals how variations in COD removal efficiency for different hydraulic and organic loads are controlled by changes in HRTs and influent concentrations, respectively.

Increasing influent COD concentrations stimulates bacterial growth, with total biomass (TB) that tends be more abundant and to occupy more CW space towards the CW outlet (Figure 1, top). Moreover, the portion of TB near the inlet shifts towards the outlet as well due to the higher inert material that is accumulated near the inlet (Figure 1, bottom). HF CW shows a good buffer capacity for organic overloads, with COD removal efficiencies even higher at the end of the simulated year compared to the beginning of the simulation (not shown). However, the response time is long due to the low growth rate of anaerobic bacteria. This results in a long transition phase (almost six months) in which COD removal efficiency is lower (from 91.3% at normal loadings to 80% for +50% organic overloading) (not shown). Additionally, feeding HF CW with higher organic loads reduces their lifespan due to higher accumulation of inert material (Figure 1).

COD removal efficiencies are also influenced by HRT. COD removal efficiency is higher in the first four months when only hydraulic loads are increased, while higher concentrations promote a higher removal efficiency in the last 8 months of the simulation.

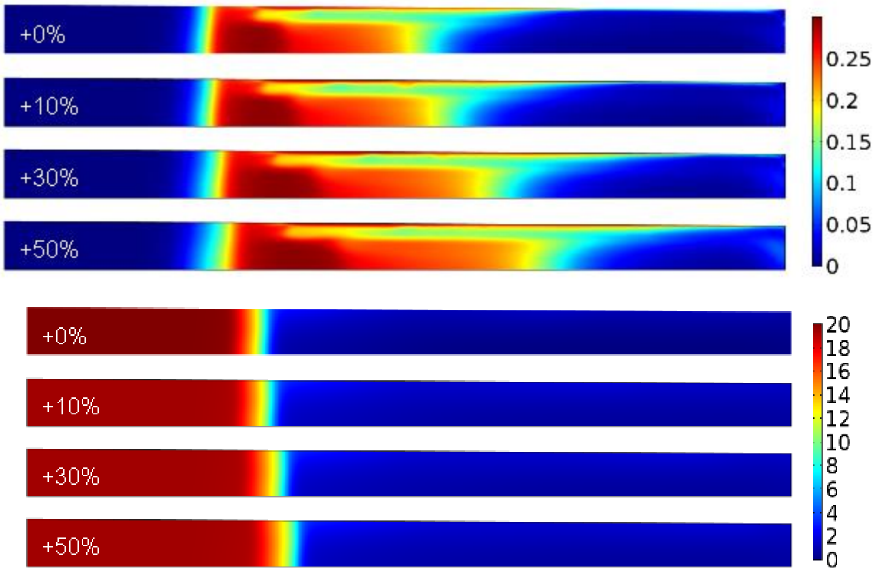


**Fig. 1. Spatial distribution of total microbial biomass (upper panels) and accumulated solids (lower panels) at the 360th day of simulation (end of the fourth year of HF-CW functioning) for different organic overloads. Values are expressed in kg m$^{-3}$.**

## CONCLUSIONS

HF CWs guarantee a good but slow buffering capacity of COD removal in response to organic overloads. This buffering capacity is achieved through changes on the total biomass and on the relative concentration of the different bacterial groups within the granular media. Moreover, we demonstrate that organic and/or hydraulic overloads reduce HF CW’s lifespan.

## REFERENCES

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