Biofilm dynamics and growth in horizontal subsurface flow constructed wetlands

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Summary

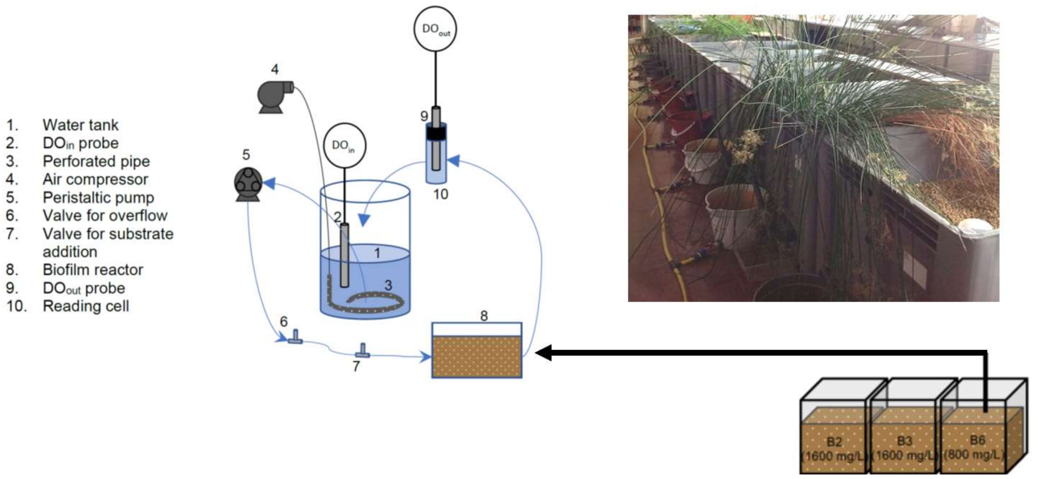
Constructed wetlands (CWs) are a natural wastewater treatment technology usually applied for small communities and widely known as sustainable and eco-friendly. However, CWs are also considered a complex treatment system, usually known as the "black-box", where all chemical, biological and physical treatment reactions take place in one single bioreactor with aerobic, anoxic and anaerobic zones.

Although CWs have been studied for a wide diversity of effluents and treatment conditions, most of the existing studies consist in point-in-time observations with countless different characteristics. In fact, their design is still based mostly on 'rules of thumb' or simple first order equations since we do not have a clear overall understanding of the interrelations of all processes taking place within these systems. To overcome these gaps, mathematical models have been developed to help improve the understanding of the natural water treatment processes and optimize the design/operation conditions of CWs. However, available CWs models use the same parameters values as Activated Sludge Models (ASM) and with fundamental differences in treatment conditions (mainly aerobic environment in activated sludge systems vs. mainly anoxic environment in CWs), more research should be focus on CW's biofilm dynamics and retrieving specific parameter values for CWs.

This thesis focal aim is to analyse horizontal subsurface flow CW's biofilm dynamics regarding substrate consumption, growth rates and consequent bioclogging phenomena. Moreover, the overall aim is to contribute to filling existing knowledge gaps identified in CW mathematical models and to further analyse and calibrate these modelling tools with experimental data. The laboratory research work was developed using lab-scale horizontal subsurface flow constructed wetlands (HSSF-CWs) and, for modulation purposes, the BIO_PORE model was used. Main outcomes of this thesis research are: development of new techniques to asse biofilm development, novel respirometric system to assess stoichiometric and kinetic parameters from attached biofilm samples, specific modelling parameters values for HSSF-CW, bioclogging rate degrees in HSSF-CW, sensitivity analysis of aerobic parameters in BIO_PORE model and an important validation of the BIO_PORE bioclogging theory on porous media using experimental data.

Keywords

Constructed wetlands, horizontal subsurface flow, bioclogging, modelling parameters, CWM1, BIO_PORE.



Respirometric system developed to assess stoichiometric and kinetic parameters from attached biofilm samples from Constructed Wetlands.