Resum de Tesi Doctoral

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Títol de la tesi	Numerical Modeling of Cosntructed Wetlands for Wastewater Treatment
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(Mínim 1 i màxim 4, podeu veure els codis a http://doctorat.upc.edu/gestio-academica/impresos/tesi-matricula-i-diposit/codis-unesco)

Resum de la tesi de 4000 caràcters màxim (si supera els 4000 es tallarà automàticament)

Constructed Wetlands (CWs) are a wastewater treatment technology that inherits the purification potential of natural wetlands and optimizes it to comply with regulations for treated discharges. CWs have become an equally performing alternative to conventional wastewater treatment technologies of communities up to 2000PE, with lower energy and maintenance costs. Despite their potential, CWs lack reliability, which holds back their full deployment in the territory. This fact results from the lack of understanding on their internal functioning and because they are prone to clogging.

The enormous diversity of CWs typologies and operation strategies, and the fact that they operate at the mercy of the environmental conditions, makes each CW unique on its kind, and experimental studies are usually only representative of the studied system. This fact makes mathematical models essential to study their functioning. Several models for CWs have proliferated in the last dozen years to provide supporting tools for their design and operation as well as more insight into the treatment processes. However, compared to models utilized in similar disciplines, CWs models are still in an embrionary stage.

Accordingly, the objectives of the current work were to develop a CWs model able to describe the most common processes taking place within CWs, and to use this model to shed light on the internal functioning of these systems in the long-term. The model, named BIO_PORE, was built in COMSOL Multiphysics and can simulate subsurface flow and pollutants transport in porous media. It also implements the biokinetic model Constructed Wetlands Model number 1 (CWM1) to describe the fate of organic matter, nitrogen and sulphur and the growth of the bacterial groups found in CWs. The model was calibrated with experimental data of a year of operation of a pilot system.

Two empirical parameters (Mcap and Mbio_max) were used to improve the description of bacterial growth obtained with CWM1 and to include the effects of solids accumulation on bacterial communities. The effect of these two parameters was evaluated using local sensitivity analysis. The model was later used to unveil the dynamics of bacterial communities within CWs. In addition, a theory was derived from simulation results, which aimed at describing the most basic functioning patterns of CWs based on the interaction between bacterial communities and accumulated solids. At the end of the document a mathematical formulation is presented to describe bioclogging and a numerical experiment is carried out to showcase its impact on simulation results.

The main outcome of the current work was the BIO_PORE model. This model was able to reproduce effluent pollutant concentrations measured during an entire year of operation of the pilot system. Parameters Mcap and Mbio_max proved essential to prevent unlimited bacterial growth predicted by CWM1 near the inlet sections of CWs. These two parameters were also responsible for the good fitting with experimental data. This was confirmed with the sensitivity analysis, which demonstrated that they have a major impact on the model predictions for effluent COD and ammonia and ammonium nitrogen. The theory derived from simulation results indicated that bacteria move towards the outlet with time, following the accumulation of inert solids from inlet to outlet. This result may prove that CWs life-span is limited, corresponding to the time after which bacterial communities are pushed as much towards the outlet that their total biomass is not able to provide effluents with acceptable quality. The inclusion of bioclogging was a requisite to reproduce the bacterial distribution and fluid flow and pollutants transport within CWs.

More work on the BIO_PORE model is required and more experimental data is necessary to calibrate and validate its results.

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