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Integrated simulation of horizontal flow constructed wetlands

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Constructed wetlands (CWs) are widespread facilities for wastewater treatment. In subsurface horizontal flow CWs, contaminated wastewater flows through a porous matrix, where oxidation and detoxification phenomena occur. Despite the large number of working CWs, system design and optimization is still mainly based upon empirical equations or simplified first-order kinetics. This results from an incomplete understanding of the system functioning, and may in turn hinder the performance and effectiveness of the treatment process. As a result, CWs are often considered not suitable to meet high water quality-standards, or to treat water contaminated with recalcitrant anthropogenic contaminants. To date, only a limited number of detailed numerical models have been developed and successfully applied to mimic constructed wetland behavior. The aim of this work is to develop a comprehensive simulator tailored to model the functioning of horizontal flow constructed wetlands and in turn provide a reliable design and optimization tool. The model is based upon PHWAT, a general reactive transport code for saturated flow. PHWAT couples MODFLOW, MT3DMS and PHREEQC-2 using an operator-splitting approach. The use of PHREEQC to simulate reactions allows great flexibility in simulating biogeochemical processes. A complex biogeochemical reaction network has been designed, based on existing process-based models for the different chemical components. Since both equilibrium and kinetic reactions are possible, changes in pH, redox potential and surface reactions can be easily incorporated. The model has been compared with published experimental data. Further to this, a sensitivity analysis has been performed to identify the main parameters

controlling the system.