ABSTRACT

Wetlands are natural systems with high capacity for the mineralization of organic matter, thanks to the intense microbial activity that occurs inside. Constructed wetlands try to reproduce, from their design, the characteristics of natural wetlands and can be used to restore ecosystems creating humid zones, as well as to purify the wastewater. Although they require a surface area clearly superior to that of the conventional systems (among 20 and 80 times superior), these systems of natural purification are simple to use, with a low or null energetic consumption, producing little waste during their operation and a low sound environmental impact and with a good integration into the natural environment.

These systems have experimented an important development in Europe and North America over the last 20 years. There are several regulations that prioritize their use for small centres of population. This expansion of the use and the complexity in physical, chemical and biotic terms of constructed wetlands, cause that the possibility for the simulation of these systems is considered both to obtain a better understanding of the processes that take place inside and to check and optimise existing design criteria.

The aim of this study is to simulate flow and reactive transport in constructed wetlands of subsuperficial flow to evaluate how variations in some of their design parameters affect to their behaviour.

The bidimensional model of simulation is based on the code RCB that previously has been applied successfully in different hydrogeological studies and simulates reactive transport of dissolved and gaseous species in non-isothermal saturated or unsaturated problems by finite elements. Possible chemical reactions include aqueous complexation, sorption, precipitation-dissolution of minerals and gas dissolution. Aqueous complexation and precipitation-dissolution can be modelled in equilibrium or according to kinetic laws. The code was modified to include the main microbiological processes related to organic matter and nitrogen removal: hydrolysis, aerobic respiration, nitrification, denitrification, sulphate-reduction and methanogenesis, using Monod expressions for the kinetic rates of these processes.

Two of the eight constructed wetlands of subsuperficial flow that form the pilot plant in Les Franqueses del Vallés (Barcelona) acted as a basis to develop the simulation model of this study. Analysis of data coming from these two constructed wetlands, only different in the size of the granular medium of each bed, allowed the calibration of a set of kinetic constants and the posterior validation of the model, obtaining a good match for simulation results.

According to the results obtained, the soluble organic matter coming from the affluent is mostly removed by the anaerobic reactions. Approximately it is made of 50% of methanogenesis, 20% of sulphate-reduction and 10% of denitrification; as opposed to 20% of the aerobic respiration. Suspended matter is eliminated practically in its whole.

It can be observed that the behaviours of both soil types are quite similar because the granular medium size and the porosity of both simulated constructed wetlands are similar too. The light difference between them indicates that the pollutants concentrations in the effluent come down to minor porosity.

Keeping constant all the values of the model excepting the affluent flow rate, the retention time changes and, therefore, the time that micro organisms have to assimilate organic matter changes too. The obtained results are coherent with this increase or decrease of the biochemical reactions, and thus, with the same variations of the effluent pollutants.

When the water level in constructed wetlands drops the retention time comes down and part of the anaerobic area gets reduced. That means an increase of the pollutant concentrations in the effluent.

If organic affluent load decreases, it can be proved that in one hand the effluent concentrations fall and on the other hand the percentage of removal of dissolved organic matter increases, so the constructed wetland works efficiently.