Modelling of biofilm growth on humic substances

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Dissolved organic carbon (DOC) has increased in concentration in many European rivers. This implies a degradation of the water used for the preparation of drinking water. Biofilms are major sites of carbon cycling in streams and rivers. At the river ecosystem level, the potential surface area for biofilm formation and the quantity and quality of available organic carbon might determine the effects of biofilm function on DOC dynamics. Humic substances, particularly humic and fulvic acids, typically account for the majority (about 75%) of the DOC found in river water (Barreto *et al.*, 2003). It is of critical importance to improve the knowledge about the uptake of DOC fractions by biofilm communities to better understand their contribution in the self-purification of surface water. In this context, mathematical modelling is an important tool to evaluate the mechanisms of heterotrophic biofilm growth. Therefore, the present work intends to model the biofilm formation in the presence of a commercial humic material (BS102M) as a carbon source. A mathematical model, **bio4B** (**bio4B**iofilms) was developed to describe biofilm growth, respiration and inactivation processes and was implemented in the AQUASIM platform (Reichert, 1994). A sensitivity analysis was also carried out using the absolute-relative sensitivity function (Sens AR) that is provided by AQUASIM. The biofilm was formed in a flow cell that simulated flow conditions in a river (laminar regime, Re = 16689). A one-dimensional biofilm structure was assumed with mass transport of soluble substrates (dissolved oxygen and humic substances) by diffusion and mass transport of particulate matter (heterotrophic biomass and inert particulate matter) by advection as a result of volume expansion due to growth. All simulations were performed with a flow cell volume of 0.382 dm^3, a biofilm area of 2.7 cm^2 and a constant humic substances loading rate of 9 $mg_{COD}.d^{-1}$. Two distinct values of maximum specific growth rate of heterotrophic biomass ($\mu_{max,H}$) were considered in the simulations: 0.5 d^{-1} during the lag phase of biofilm growth and 5 d^{-1}, afterwards. Basic model parameters were taken from Wanner and Reichert (1996) and Horn *et al.*, (2003). The total countable cells in the biofilm, determined over ten weeks, were used for model calibration. The cell numbers were transformed in chemical oxygen demand (COD) considering that one cell weighs $9.5x10^{-13}$ g and that 1 g of cells has 1.42 g of COD (Gaudy *et al.*, 1964). The biofilm concentration in the presence of humic material is presented in Figure 1.

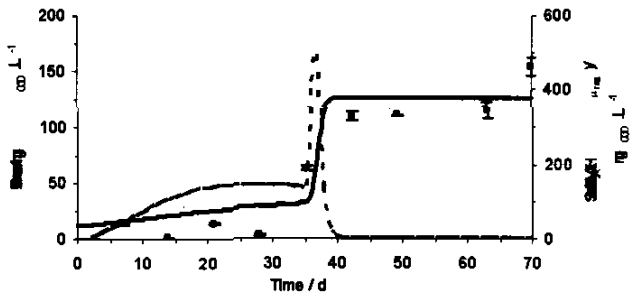

Figure 1 – Biofilm concentration during 10 weeks. The black line is the simulation and the marks are the experimental data with the standard deviation. The hatched line is the sensibility (Sens AR) of $\mu_{max,H}$ relatively to biofilm concentration.

The simulation results describe quite well the experimental data. Three distinct biofilm growth phases can be observed: a lag phase during the first 35 d, corresponding to the adaptation/selection of the microorganisms to the humic material, an exponential growth phase and a stationary phase after the 40th day. The sensibility analysis of model parameters relative to XH have shown that □max,H is the parameter presenting the highest sensibility followed by the inactivation rate constant and the initial density of bacteria. During the exponential phase the sensibility presented a peak due to the faster increase in XH concentration.

Keywords biofilm; mathematical modelling; humic material