Analysis of the influence of growth conditions on the competition between biological aggregate morphotypes: biofilms, flocs and streamers

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The morphological and physical properties of biofilms, and the fractions of each morphotypes are very important for the stability and performance of a biofilm reactor (Filali et al., 2012; Telgmann et al., 2004) and strongly impact on the efficiency of biofilm removal in industrial water pipes (Pechaud et al., 2012).

In this study, we focus in analyzing the influence of operating conditions on the competition between 3 aggregate morphotypes in biofilm reactors: biofilms, flocs and streamers.

The main objectives are: (i) to improve understanding of the mechanisms controlling the competition between the three microbial morphotypes and (ii) to analyze the dynamics of streamers formation. The influence of the substrate residual concentration, the surface organic loading rate (SOLR) and the carbon source on the fractions of the various morphotypes and their impact on the substrate removal efficiency is assessed. In order to modify the residual concentration of substrate in the bulk without changing the SOLR, the hydraulic retention time (HRT, i.e. the average time spent by the liquid in the reactor and is equal in our condition to the suspended solid retention time) was changed. The HRT governs the dilution rate of substrates and thus the substrate concentration in the liquid but also the detached particles retention time. Moreover, for streamers, the morphological properties (ratio length/diameter of the streamers, amplitude of oscillation) and the kinematic parameter (frequency of oscillation) were quantified at two times of their development.

At low HRT (3h) which induced lower carbon substrate concentrations in the bulk, development of streamers is favored and suspended particles in the liquid and biofilm are disfavored. On contrary for high HRT (20h), detached particles and biofilms were the dominant aggregate morphotypes. This difference of predominance in morphotypes has been attributed to three main factors: the SRT of SS, the residual concentration in the bulk liquid and the hydrodynamic conditions of growth (mass transfer and shear stress). Turbulent conditions and a low substrate concentration considerably favored the development of streamers which benefit from the higher external mass transfer. Indeed compared to biofilms the flapping movement and the higher surface to volume ratio of streamers increase the global external mass transfer. In some conditions, the mass of streamers in the reactor were closed to the biofilm one's, highlighting the necessity to consider such morphotypes in further studies since they can have a significant impact on treatment efficiency.

Concerning the dynamics of streamers formation, a densification of the streamers was observed over time (30 days of growth). From these results and theoretical considerations, assumptions on the mechanisms responsible for the development of streamers are proposed.

**Key-words**: Biofilm, streamers, transport, detachment, competition.


