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IAWQ SPECIALIST GROUP ON

BIOFILM SYSTEMS

CHAIRMAN
Mark van Loosdrecht
Dept. of Bioprocess Technology
Delft University of Technology
Julianalaan 67
2628 BC Delft
THE NETHERLANDS
phone: +31-15-2781618
fax: +31-15-2782355
e-mail: mark.vl@stm.tudelft.nl

SECRETARIES
Hans-Curt Flemming
TU München
Wassergutewirtschaft
Am Coulombwall
D-85748 Garching
GERMANY
phone: +49-89-3209 3706
fax: +49-89-3209 3718
e-mail:
100255.3727@compuserve.com

Yoshimasa Watanabe (asia-pacific region)
Dept. of Environmental Engineering,
Faculty of Engineering, Hokkaido
University, N13 W8
Sapporo 060
JAPAN
phone: +81-11-7162111
fax: +81-11-7067890
e-mail:
watanabe@sany.hokudai.ac.jp

EDITOR
Maarten A. Siebel
International Institute for
Infrastructural, Hydraulic and
Environmental Engineering (IHE)
P.O. Box 3015
2601 DA Delft
THE NETHERLANDS
phone: +31-15-2151784
fax: +31-15-2122921
e-mail: mas@ihe.nl or biofilm@ihe.nl

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BIOFILM THICKNESS AND DENSITY: EFFECTS AND INFLUENCE

Tejero, I.; Lorda, I.; Jácome, A.; Vidart, T.; Eguía, E.; Amieva, J. and Bezanilla, J.

Equipo Biopelícula. Departamento de Ciencias y Técnicas del Agua y Medio Ambiente. Universidad de Cantabria. Avda. de los Castros, s/n. 39005 Santander (Spain).

INTRODUCTION

The objective of this study was to analyse the influence of some of the process variables and characteristics of the reactors used on the density and thickness of biofilm. The influence of density and thickness on process performance was also analysed. The following variables have been considered: the organic load applied, and the biofilm age. The biofilm system characteristics were: the way of supplying oxygen, either combined oxygen-substrate flow (RBC) or counter-current flow (PSBR). The influence of thickness on process performance was characterised according to the organic load removed. The process performance was also studied using a supply of both pure oxygen and air.

MATERIALS AND METHODOLOGY

Synthetic waste water with glucose as carbon source was used. Two PSBRs worked with oxygen (Eguía, 1991) and air (Vidart, 1992), and with different volume: 10.7 dm^3 y 1.5 dm^3, respectively. The flow in the reactors was completely mixing. The maximum flow of gas was limited for permitting the same oxygen mass flow when oxygen and air were used. One RBC system used (Bezanilla, 1993) consisted of two pilot plants: one with alternating feed, the results of which were compared with a second one that operated using a conventional process. Discs' diameter was 160 mm. It worked with 13 rpm and constant hydraulic load. The other RBC system (Amieva, 1993) was a reactor of four stages, which worked with extraction of the complete stage when the biofilm thickness was larger than a certain value. The removed stage was replaced with other one with clean discs. Therefore, this RBC worked in a transitory state of the biofilm. In this reactor, discs' diameter was 180 mm and rotational speed was 16 rpm. The biofilm thickness was measured by gravimetric technique (Jácome, 1990) and microscopic technique (Trulear and Characklis, 1982).

RESULTS AND DISCUSSION

With RBC, plants (alternating feed and conventional process) operating in steady state of biomass growth (Bezanilla, 1993), we find that the maximum thickness of equilibrium reached at every stage is a lineal function of the organic load applied and removed (Fig. 1). This plant can support double the applied load than the control plant without clogging of discs. For similar organic loading and with RBC working in a transitory state (Amieva, 1993) biofilm sloughing was produced with thickness lower than those indicated in Fig.1. This could be owing to the greater shear stress involved (peripheral velocity = 0.15 m/s vs. 0.109 m/s) and possibly to lower influent substrate concentration (200 mg COD/L vs. 450 mg COD/L).

With PSBR working with different steady states of substrate removal but without searching for the steady state of biofilm growth it seems that exists an influence of the substrate loading on the biofilm thickness. Although this influence appears reasonable it could be affected by the progress of the experiment, i.e. by the biofilm´s age (Fig. 2). The thickness tends to increase with the biofilm's age. This tendency does not grow constantly owing to the variations in the organic load applied on the process.

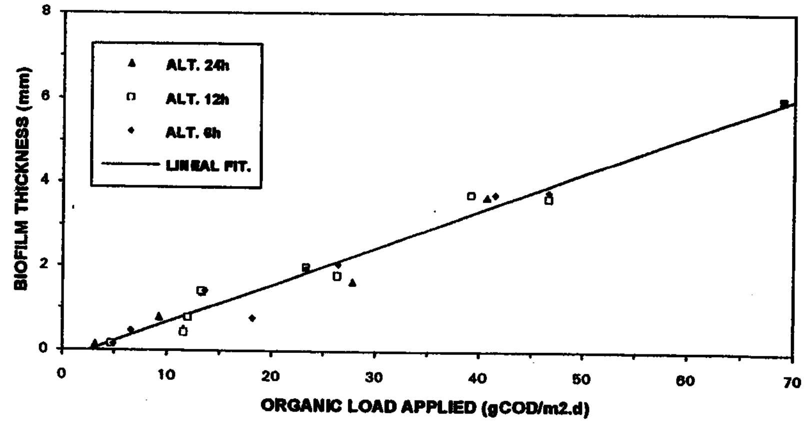

Fig. 1. Influence of organic load applied on biofilm thickness (RBC).

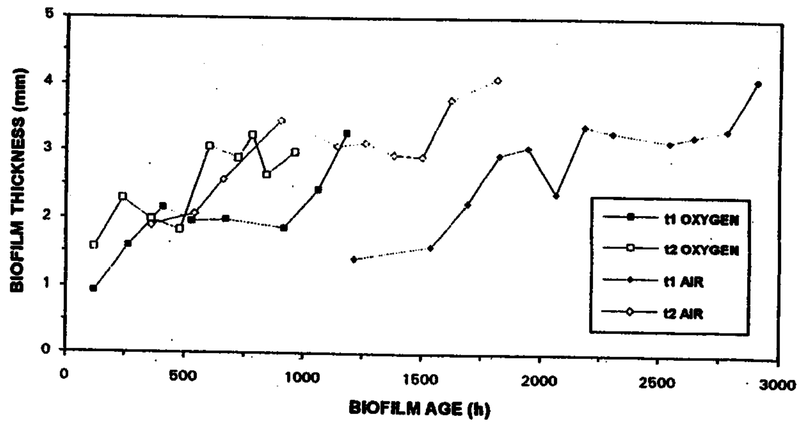

Fig. 2. Influence of biofilm age on biofilm thickness (PSBR).

The results obtained with RBC (Amieva, 1993) confirm those reported by Hoehn and Ray (1973) for thick biofilms with co-current flow of substrate and oxygen (traditional biofilm): low densities (20-30 kg/m^3) independent of thickness (Fig. 3). However, with the counter-current flow biofilm obtained in PSBR the maximum densities quoted (90-105 kg/m^3) are reached but with thicknesses between 1mm and 4 mm. These densities are greater using oxygen (Eguía, 1991) than using air (Vidart, 1992). A slight increase in density is also seen with increased thickness which is more pronounced in the case of air (Fig.3).

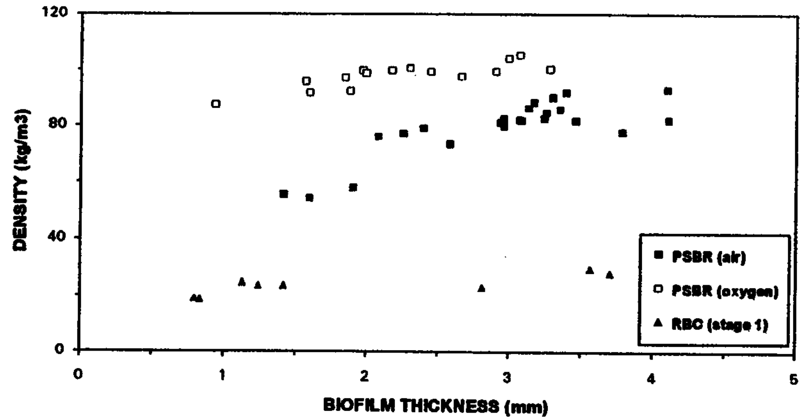

Fig. 3. Comparison of relationship between biofilm density and biofilm thickness in PSBR working with air and oxygen and in RBC.

The explanation for the high density of the counter-current flow biofilm comes from the different growth patterns, not on the surface (biofilm-water interface) but near the substratum (biofilm-substratum interface). In this location, similar conditions permanently exist to those found in the initial formation of traditional biofilms until the active thickness is reached. In those conditions higher densities are obtained for traditional biofilms. Therefore, the counter-current flow biofilm will constantly produce a dense matrix which is displaced towards the surface by the new biofilm growth. Based on findings of Masuda *et al.* (1991) we can deduce that in the active layer of the counter-current flow biofilm there exists a greater cell concentration, and based on Zhang and Bishop (1993) a maximum activity takes place. The greater densities obtained using oxygen instead of air may indicate a greater penetration of oxygen in bacterial aggregates of the biofilm. This may permit the survival of a greater number of cells per unit volume (reducing porosity).

It was found that removed substrate flux decreases as biofilm thickness increases in PSBR (Fig. 4). This may be caused by an increase in diffusional length of the substrate since the inactive layer of the biofilm is located between the active layer and the bulk water. It can also be noted that by using oxygen a greater elimination of carbonaceous substrate removal is obtained than by using air for the same organic loading.

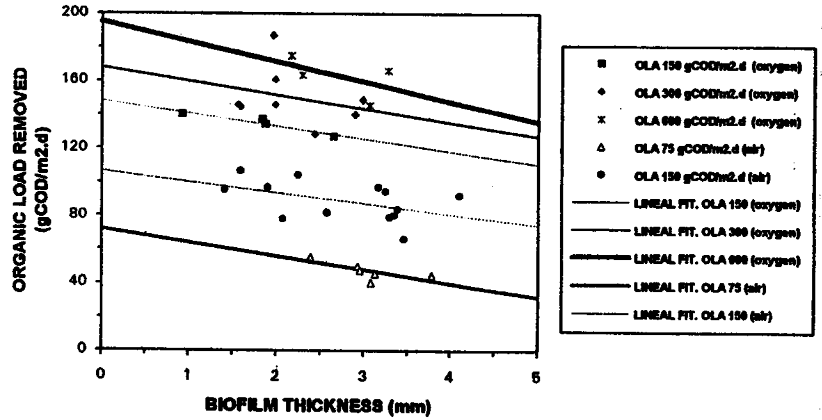

Fig. 4. Influence of biofilm thickness on organic load removed in PSBR.

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