SIMULTANEOUS REMOVAL OF ORGANIC MATTER AND NITROGEN OF MUNICIPAL WASTEWATER IN A BIOMEMBRANE REACTOR WITH AUTOAERATED BIOFILMS

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Introduction

The biofilms developed on synthetic hydrophobic gas permeable membranes form a system named biomembrane. In this system the oxygen and the nutrients are supplied in counter-current diffusion. The nutrients diffuse from the bulk liquid through the biofilm whereas the oxygen or air diffuses through the membrane. When the aeration is realised means atmospheric pressure we are talking about autoaerated biofilms.

Experimental procedure

In this work a bench scale biomembrane reactor was operated to study the kinetics of combined removal of organic matter and nitrogen of municipal wastewater (Fig. 1). The reactor was constructed with Plexiglas. A of the walls of the reactor was constructed with a synthetic membrane of di-fluoro polyviniliden, Durapore®, with a pore size of 0.22 μm and area for the biofilm growth of 36 cm^2. The volume of the reactor was 500 mL. A paddle stirrer was used for completely mixing of the bulk liquid.

The reactor was fed with a primary effluent of an average diary composition (all values in mg/L, excepting pH): pH = 7.2; COD = 55; NH_4^+-N = 7.55; NO_3^--N = 0.77;

VSS = 7.94; Org. N = 5.63; DO = 3.30. Bi-weekly, was measured NO_2^--N and alkalinity (as $CaCO_3$) which average values were 0.01 mg/L and 100 mg/L, respectively. In the effluent were measured the same parameters than in the influent and with the same periodicity.

The simultaneousness of the growth bacterial reactions was proven by means of mass balances. The half-reaction of electron donator by the McCarty's method (1975) was:

$$0.16\ C_{1.79}H_{1.78}O_{0.97}N_{0.21} + 0.41\ H_2O \rightarrow 0.28\ CO_2 + 0.03\ NH_4^+ + 0.97\ H^+ + e^- \quad (1)$$

In a sample of biofilm were determined wet weight, dried weight, and volatile solids. These analyses were made in all biofilm developed on plate membrane substratum. The biofilm thickness was calculated by:

$$L_f = 10\,000\ w/(\rho_w\ A) \quad (2)$$

In the Eq. 2, L_f = biofilm thickness (μm); w = wet weight of the biofilm (g); ρ_w = water density (g cm^{-3}) and A = biofilm area (cm^2).

In order to analyse the kinetics of removal of organic matter and nitrogen the reactor was operated in a wide range of applied superficial loading. The organic loading fluctuated from 30 to 160 g COD m^{-2} d^{-1}. The nitrogen loading fluctuated from 12 to 72 g N m^{-2} d^{-1}. These variations of loads were produced, principally, by changes of the influent volumetric flow rate. The hydraulic retention time fluctuated from 1.2 to 7.8 h.

Results and discussion

During all the experience the growth of the biofilm was developed on the plate membrane support. On the other walls of the reactor the development of biofilm was negligible. The effluent concentration of suspended biomass varied from 4 to 6 mg VSS/L. The characteristics of the biofilm analysed are shown in the table 1:

Table 1. - Characteristics of the biofilm

Age (days)	X_a (g VS/m^2)	L_f (Eq. 2) (μm)	X (g VS/m^3)
125	35.53	1,143	31,074

X_a: superficial density biofilm

X: volumetric density biofilm

The simultaneousness of the biological reactions was proven by mass balances (Fig. 2). The nitrification rate is able to achieve values of 7.4 g NH_4^+-N m^{-2} d^{-1}. The denitrification rate achieves a maximum value of 7.6 g NO^-_3-N m^{-2} d^{-1}. The heterotrophic oxidation reaches a maximum value of 49 g COD m^{-2} d^{-1}.

The removed organic loading, r_A, ranged from 10 to 49 g COD m^{-2} d^{-1}. The removed total nitrogen loading varied from 0.64 to 8.32 g N m^{-2} d^{-1}. The COD and nitrogen removal rates did not have a clear trend with respect to B_A (Fig. 3).

Due to the nitrification and aerobic heterotrophic oxidation rates the maximum flux of oxygen exhausted would be of 46 g m^{-2} d^{-1}. The oxygenation capacity by atmospheric pressure of the system without biofilm ranged from 4 to 6 g O_2 m^{-2} d^{-1}. Therefore, the enhanced transference of oxygen is produced by the biofilm developed on plate membrane support.

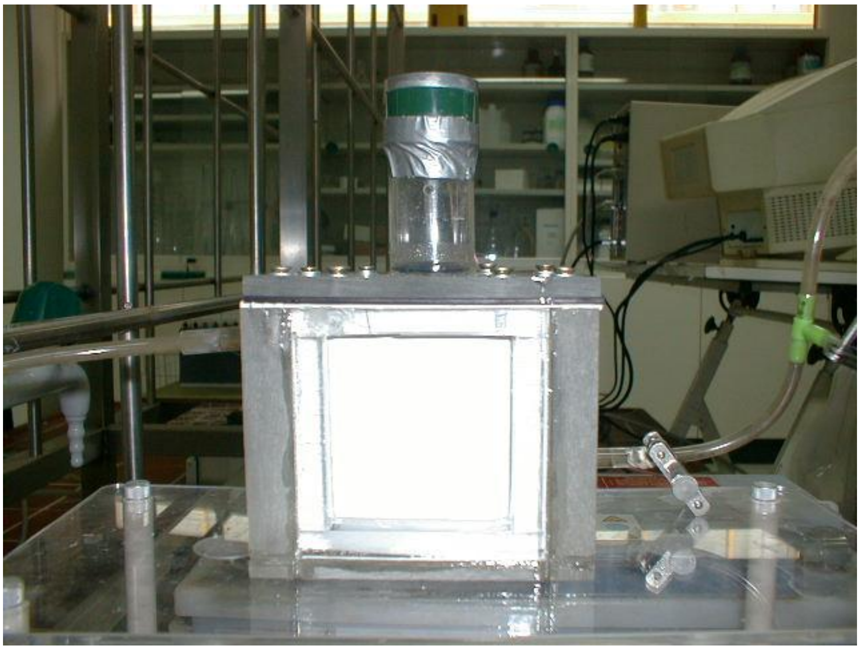

Figure 1.- Photograph of biomembrane reactor

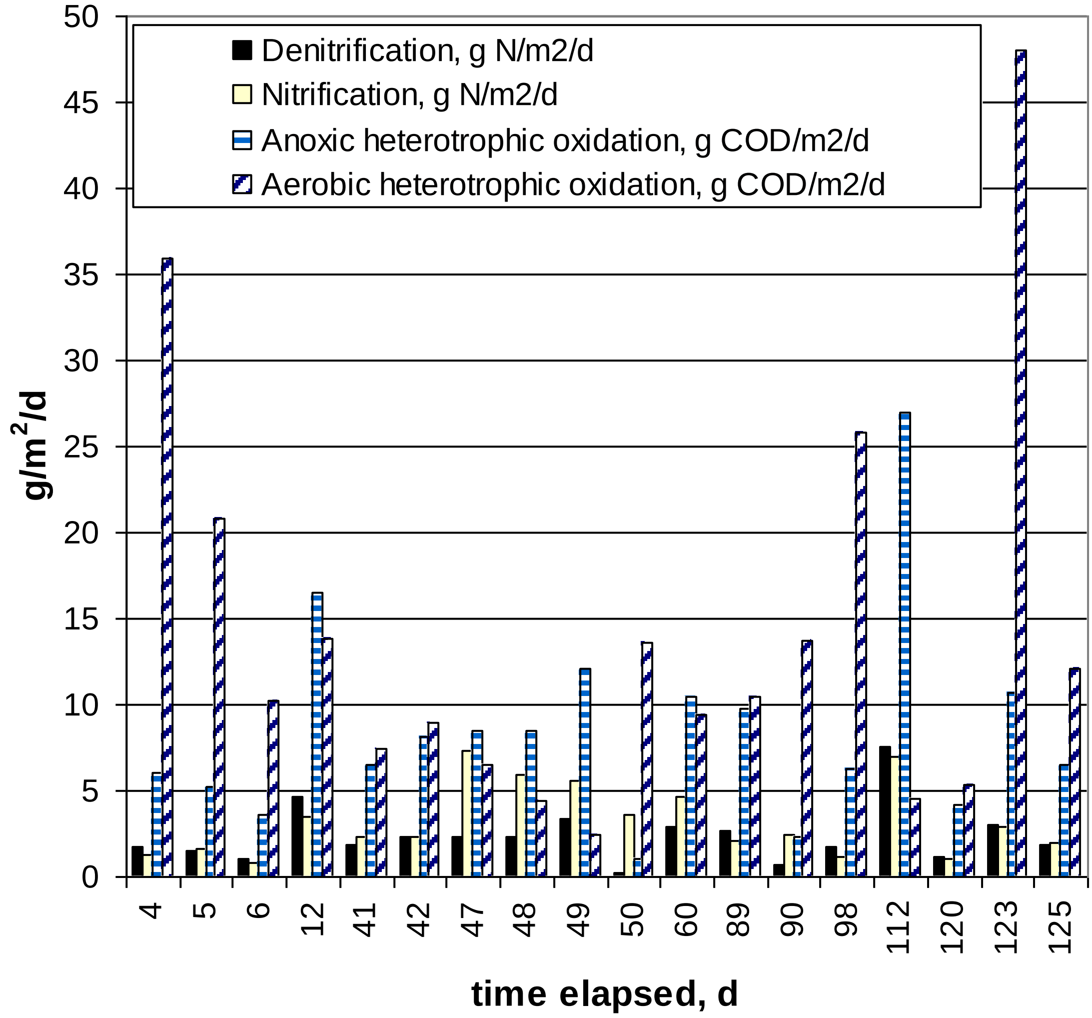

Figure 2.- Removal rates of COD and Nitrogen

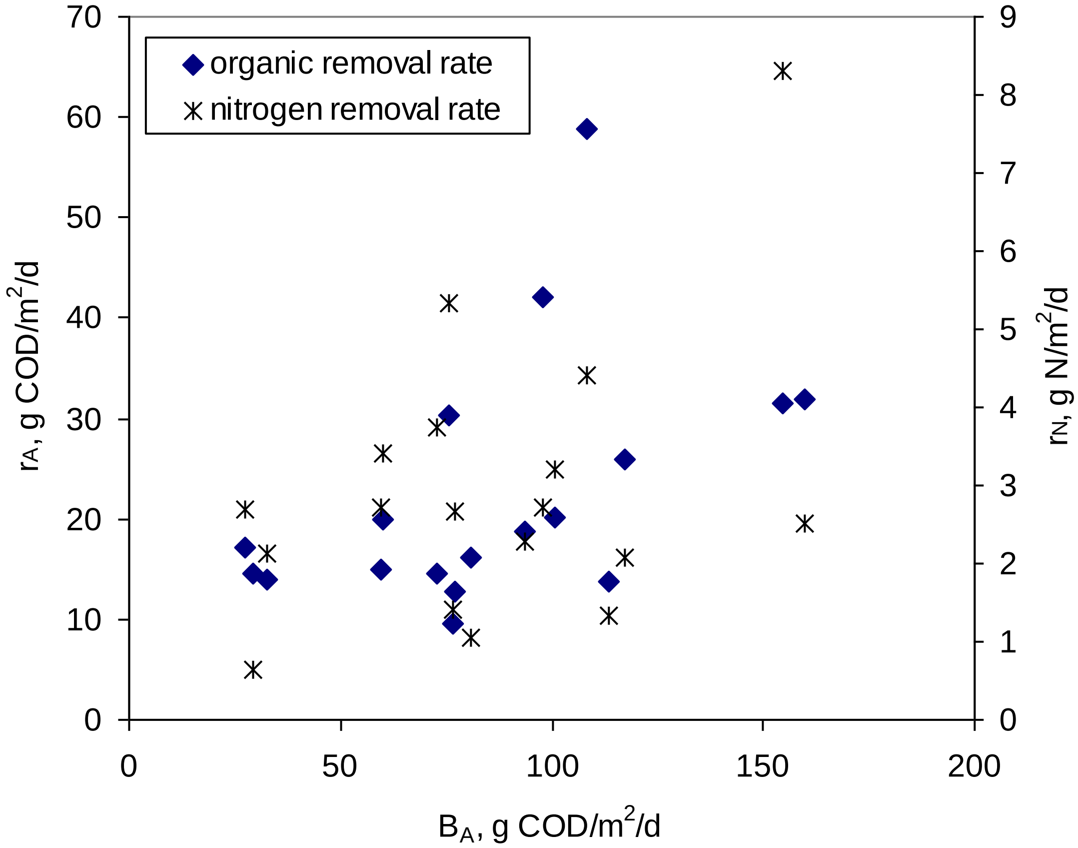

Figure 3.- Removal kinetics of COD and Nitrogen