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# ОБЕСЦВЕЧИВАНИЕ АЗО-КРАСИТЕЛЯ В НИСХОДЯЩЕМ АЭРОБНОМ БИОПЛЕНОЧНОМ РЕАКТОРЕ, СОДЕРЖАЩЕМ *OPUNTIA IMBRICATA* В КАЧЕСТВЕ НОСИТЕЛЯ

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**Дано описание методики использования нисходящего колоночного аэробного реактора, заполненного *Opuntia imbricata* (природный носитель), для разложения текстильного красителя и удаления ХПК. Кинетические исследования показали, что скорость удаления ХПК зависит от времени гидравлического задержания (ВГЗ), и начальная скорость удаления ХПК увеличивается с увеличением ВГЗ. Рост скорости аэробной биодеградации наблюдали при увеличении ВГЗ от 24 до 34 ч, далее рост был незначителен. Максимальная эффективность удаления ХПК (90%) достигалась при 34 ч. Начальная скорость аэробной биодеградации ХПК, определяемая как функция нагрузки по органическим загрязнениям, описывалась кинетической моделью псевдопервого порядка. Показано, что в биопленочном реакторе, заполненном природным носителем, происходит эффективное обесцвечивание и биодеградация ХПК.**

## Introduction

Wastewater discharged from dyeing process in the textile industry has always been a major source of water pollution because most dyes are highly colored and difficult to be removed by conventional wastewater treatment systems. The dyeing wastewater treatment should not only be concentrated on the reduction of parameters such as chemical oxygen demand (COD), biochemical oxygen demand (BOD) and total organic carbon (TOC), but also on reducing color intensity of the effluent [1]. One of the major problems associated with the treatment of textile wastewater is the removal of dyes. Most (60–70%) of the more than 10,000 dyes applied in textile processing industries are azo compounds, i.e. molecules with one or more azo (N=N) bridges linking substituted aromatic structure [2]. Discharge of azo dyes is undesirable not only for aesthetic reasons but also because many azo dyes and their breakdown products are toxic to aquatic life [3] and mutagenic to humans [4]. Most of the published studies on azo dyes color removal involve anaerobic mixed cultures and there is some interest to gain knowledge on the process of dye reduction [5].

This paper describes the use of an aerobic column reactor packed with coyonoxtle (*Opuntia imbricata*) as a support for the formation of a biofilm. Coyonoxtle is an abundant shrub in the northeast region of Mexico and is therefore easy to obtain. Biofilm reactors are viable alternatives for the development of stable microbial populations with great activity and for efficient biodegradation of wastewater when compared to other conventional treatment processes [6–8]. The biofilm behavior depended on the type of support used [9, 10].

The present paper reports on study of aerobic degradation of textile dye containing wastewater and the COD removal in this process. The objective of this work was to investigate the effects of HRT on the removal of color and COD from the textile dye wastewater.

## Methods

A biofilm column reactor packed with coyonoxtle (*Opuntia imbricata*) was used in this study. Textile wastewater with 1.5 to 4.0 g of COD/L and 0.3 to 1.1 g/L of dye concentration was continuously fed to the reactor from the top. The removal of dye and COD was induced by various microorganisms which were attached on the surface or entrapped in the pores of the support. The treated water was collected from the outlet of the reactor for further chemical

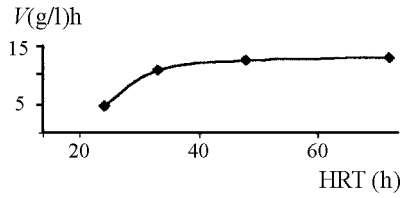


Fig. 1. Kinetic of COD biodegradation of azo dyes from textil industry wastewater as function of HRT

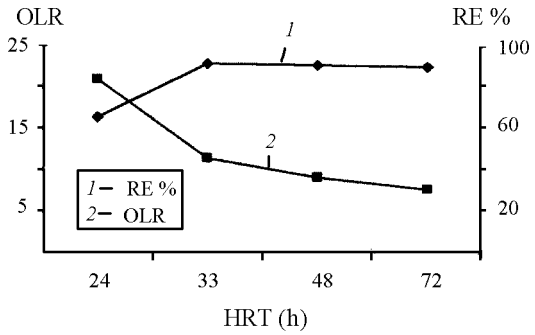


Fig. 2. Removal efficiency and Organic loading rate as function of Hidraulic Retention Time

analysis. Decolorization experiments were conduced under four HRT (24, 34, 48 and 72 h), which was achieved by increasing the influent flow rate stepwise. Other operational parameters, including the COD concentration (4 g/L), temperature (37°C) and pH (7.121) were maintained constantly. The decolorization performance was evaluated by measuring color and COD in the effluent samples. Color was determined using a Beckman DU-650 spectrophotometer. Chemical oxygen demand was analyzed according to standard methods [11]. The steady state of the decolorization process in the system was computed using the mean of three samples for the tested parameters.

## Results and Discussion

Fig. 1 showed the velocity of COD removal from textile wastewater as a function of HRT and the initial velocity of COD removal increased with HRT, until 34 h. The maximum removal efficiency was reached with 34 h HRT, which corresponded to an organic loading rate (OLR) of approximately 10 g/L/day (Fig. 2). COD removal efficiencies obtained in this study (90%) was in agreement with the results of a previous study [12]. The velocity of COD degradation was a function of OLR, which indicated the reaction as a pseudo-first-order-kinetic (Fig. 3).

The decolorization of dye as a function of HRT and color removal occurred at all HRT, but the maximum efficiency was achieved at 34 h (Fig. 4). At this HRT, the efficiency of colour removal was 95%. At 24 h HRT, the colour removal efficiency was only 53% and the velocity of removal was much less. These results indicated that the rate of decolorization depended initially on HRT.

The effect of dye concentration on the velocity of decolorization is presented in Fig. 5. It was observed that velocity increased when the dye concentration was increased, until a concentration of 1 g/L. Above this value the velocity decreased. This could be due to the accumulation of dye metabolites in the reactor [5].

The kinetic evaluation of decolorization process is shown in Fig. 6. The results showed the kinetic constant ($2.9´10^{-2}.h^{-1}$) of azo dye decolorization in aerobic biofilm column reactors. The results demonstrated that the course of decolorization process approximates pseudo first order kinetics with respect to dye concentration, as previously reported by Wuhrmann et al. [14], Carliell et al. [15] and van der Zee et al. [13]. They

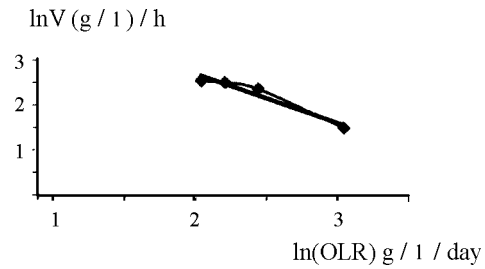


Fig. 3. Kinetic of biodegradation of COD in function of biodegradation velocity as function of Organic loading rate

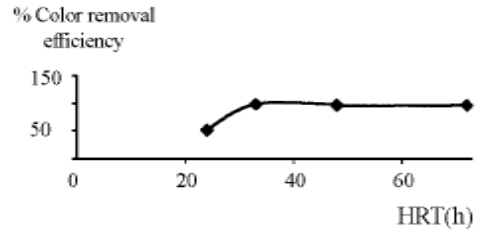


Fig. 4. Effect of Hidraulic retention time on the azo dye removal color from textil wastewater

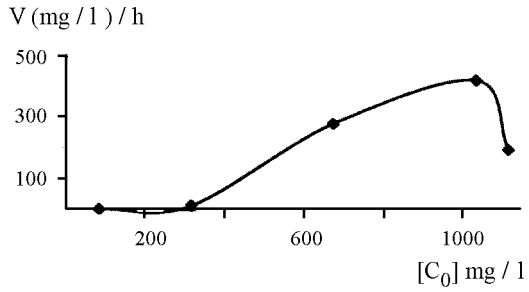


Fig. 5. Effect of colorant concentration of azo dye of textil industry wastewater on reaction velocity of decolourisation

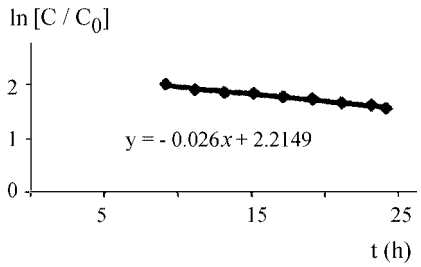


Fig. 6. Kinetic evaluation of decolourisation process in the treatment textil wastewater

reported a kinetic constant of 1.0 and $2.5^{-}10^{-2}h^{-1}$ for blue and black dye respectively under anaerobic conditions. The kinetic constant in terms of dye concentration can be represented by the following equation used by van der Zee et al., [13], Shu et al. [16] and Galindo and Kalt [17].

$$\ln\ [C/C_0] = -kt.$$

$C_0$: initial dye concentration at time ($t$) = 0; C: dye concentration at instant time, $t$; $k$: pseudo-first-order rate constant.

Numerous research studies had been done on the various decolorization techniques including coagulation, activated carbon adsorption, filtration, chlorination, ozonation, Fenton's reagent oxidation and electrochemical methods [18] but the reports on processes of aerobic biodegradation are few.

According to O'Neill et al. [19], many dyes used by the textile industry cannot be degraded and hence decolorized aerobically. In this study an efficient form of color removal by aerobic biofilm column reactor was established.

## Conclusions

The results of this study indicated that aerobic biofilm column reactor packed with coyonoxtle as support reduced and decolorized textile azo dye containing wastewater. The maximum rate of decolorization was achieved at 34 h HRT. Removal efficiency was 91 and 98% for COD and color respectively. The results also showed that the COD removal and decolorization process followed a pseudo-first-order kinetic model. The study showed that the use of aerobic biofilm column reactor required shorter time for removal of color and COD than an activated sludge aerobic reactor, in this sense, this paper report better results than others studies about aerobic process to azo dyes biodegradation.

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# AZO DYE DECOLORIZATION IN A DOWN FLOW AEROBIC BIOFILM REACTOR WITH *OPUNTIA IMBRICATA* AS SUPPORT

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**Wastewater discharged from dyeing process in the textile industry is a major source of water pollution because most dyes are highly colored and difficult to remove by conventional wastewater treatment systems. This paper describes the use of a down flow column aerobic reactor packed with *Opuntia imbricata* (Natural Support) in the degradation of textile dye and the COD removal. The kinetic results showed that the velocity of COD removal is a function of HRT and the initial velocity of this removal increased with HRT. An increase in aerobic-biodegradation velocity was observed when HRT was increased from 24 to 34 h and thereafter the increase was not significant. The maximum removal efficiency was reached with 34 h of HRT. It can be concluded that 34 h of HRT is sufficient to reach about 90% of COD removal. Initial velocity of aerobic biodegradation of COD was defined as a function of organic loading rate, and was pseudo-first-order-kinetic model. The results of this study indicated that there was an efficient colour removal and degradation in the biofilm reactor packed with natural support. The kinetics of azo biodegradation in biofilm reactor is not yet fully investigated.**