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Effect of phenol on the biological treatment of wastewaters from a resin producing industry

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Abstract

The effect of phenol on the biological treatment of wastewaters from a resin producing industry was analyzed in a pre-denitrification system. First, the effect of phenol overloads on the removal of organic matter and nitrogen compounds was studied. During the overloads (from 250 to 4000 mg/L), phenol was detected in the effluent of the anoxic reactor but the system recovered fast after stopping the overloads. The total organic carbon (TOC) removal remained unchanged during phenol addition (91.9% at 0.20 kg TOC/m^3 d), except for the highest overload. With regard to total Kjeldahl nitrogen (TKN), its mean removal (87.9% at 0.08 kg TKN/m^3 d) was not affected by the phenol overloads. Afterwards, the effect of different phenol concentrations on the biological treatment of these wastewaters was analyzed. Phenol concentrations from 250 to 4000 mg/L were added to the feed. Phenol was completely removed despite the presence of other carbon sources in the wastewater. In spite of the presence of phenol, a TOC removal around 91.3% was achieved at an average organic loading rate of 0.11 kg TOC/m^3 d. The mean applied nitrogen loading rates were 0.05 and 0.08 kg TKN/m^3 d, obtaining TKN removals around 85.8% and 87.1%, respectively. Therefore, the biological treatment of wastewaters from a resin producing industry in a pre-denitrification system was not affected by the presence of phenol.

Keywords: Phenol; Industrial wastewaters; Biological treatment

1. Introduction

Wastewaters from resin producing industries are characterized by the presence of organic matter and nitrogen compounds. Consequently, the biological treatment of these wastewaters requires a combined process for carbon and nitrogen removal. This biological treatment could be carried out in a pre-denitrification system which avoids or decreases the need of an external carbon source, which is important from an environmental and economic point of view. Organic matter removal, hydrolysis of nitrogen compounds and denitrification of nitrate recirculated from the aerobic unit would take place in the anoxic reactor. Nitrification of ammonium provided by the anoxic unit and biodegradation of the organic matter that would not have been removed in the anoxic reactor would take place in the aerobic reactor.

Cheng et al. (1996) studied the treatment of wastewaters from a resin producing industry using a pre-denitrification system (anoxic–aerobic–aerobic) at lab scale. Efficiencies of chemical oxygen demand (COD) and total Kjeldahl nitrogen (TKN) removal around, respectively, 95.3% and 83.8%, were achieved at organic loading rates between 0.27 and 0.72 kg COD/m^3 d and nitrogen loading rates between 0.04 and 0.12 kg TKN/ m^3 d. Garrido et al. (2000) also analyzed the treatment of wastewaters from a resin producing industry using a pre-denitrification system (anoxic–aerobic) at lab scale. At organic loading rates from 0.7 to 1.9 kg COD/m^3 d, the COD removals were between 70% and 85%.

The composition of wastewaters from resin producing industries is dependent on the manufacturing process. Phenol is not typically present in these wastewaters but odd

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effluents with high concentrations of this compound are generated when the manufacturing process is changed. Therefore, it is necessary to study the effect of phenol on the biological treatment of these wastewaters. In spite of being a toxic compound there are several references about phenol biodegradation under both anoxic (Blaszczyk et al., 1998; Sarfaraz et al., 2004; Eiroa et al., 2005) and aerobic conditions (Buitrón et al., 1998; González et al., 2001; Yamagishi et al., 2001; Amor et al., 2005).

The aim of this work was to analyze the effect of phenol on the biological treatment of wastewaters from a resin producing industry in a pre-denitrification system. First, the effect of phenol overloads on the removal of organic matter and nitrogen compounds was studied. Afterwards, the effect of different phenol concentrations on the biological treatment of these wastewaters was analyzed.

2. Methods

2.1. Analytical methods

Phenol was determined using a Hewlett–Packard 1100 liquid chromatograph equipped with a C-18 ODS column (25 cm × 4 mm ID). The mobile phase was methanol:water (60:40) and detection was performed at 280 nm. Methanol was measured using a Hewlett–Packard 5890-II gas chromatograph equipped with a Nukol column (30 m × 0.25 mm ID) and a flame ionization detector. Nitrogen (1.5 mL/min) was utilised as carrier gas. Injector and detector temperatures were 250 and 270 °C, respectively. Formaldehyde was analyzed spectrophotometrically according to the Hantzch reaction (Nash, 1953), using a Perkin–Elmer Lambda 11 UV/Vis spectrophotometer. Total organic carbon (TOC) was determined according to *Standard Methods* (APHA et al., 1998) using a TOC-5050A Shimadzu.

Nitrite and nitrate were analyzed by capillary electrophoresis using a Hewlett–Packard ^{3D}CE system with a microcapillary tube of fused silica (40 cm × 50 μm ID). UV detection was undertaken at a wavelength of 214 nm and 450 nm as reference. The biogas composition (N_2, CH_4, CO_2 and N_2O) was analyzed on a Hewlett–Packard 5890-II gas chromatograph equipped with a Porapack Q W80/100 column (2 m × 1/8'' ID) and a thermal conductivity detector. Helium (15 mL/min) was utilised as carrier gas. Injector, oven and detector temperatures were 90, 25 and 100 °C, respectively. Ammonium, pH, total Kjeldahl nitrogen (TKN) and volatile suspended solids (VSS) were evaluated according to *Standard Methods* (APHA et al., 1998).

2.2. Lab-scale reactor

The pre-denitrification system (Fig. 1) consisted of an anoxic upflow sludge blanket reactor (0.8 L) and an aerobic activated sludge reactor (1.8 L) (Eiroa et al., 2006). The system was provided with a liquid displacement biogas measurement device (Veiga et al., 1990). The feed to the anoxic reactor was supplied by a peristaltic pump and its effluent was continuously fed to the aerobic reactor. Diffusers, located at the bottom of the aerobic reactor, supplied air from an air pump and maintained complete mixing. The water was separated from the sludge in the settler and the sludge was recycled intermittently to the aeration basin. Part of the effluent of the aerobic unit was recirculated to the anoxic reactor by another peristaltic pump.

The reactors were inoculated with sludge from the full-scale wastewater treatment plant of a resin producing industry. Assays were performed in a thermostatic chamber at 20 °C. The feed consisted of wastewaters obtained at different times from the industry mentioned above; the composition of these wastewaters is shown in Table 1.

The concentrations of the different parameters in the feed (F) and in the effluent of the anoxic (D) and aerobic reactors (N) are presented in the figures. Mass balances with regard to the feed were performed in order to calculate

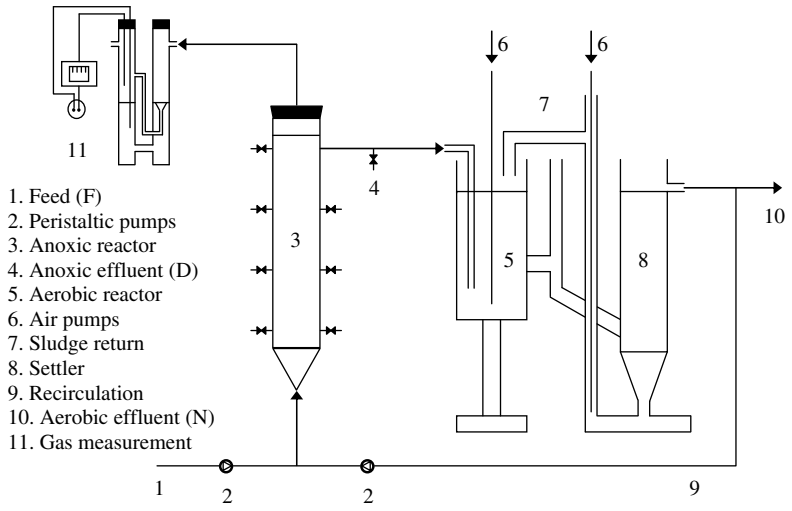

Fig. 1. Scheme of the pre-denitrification system.