Toxicity assessment of Advanced Oxidation Processes by means of respirometric measurements

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Introduction

Biological treatment of wastewater is often the most cost effective alternative when compared to other treatment methods. However, the presence of toxic and/or non-biodegradable persistent organic substances in wastewater are harmful to the biological process. In order to resolve this drawback, the use of Advanced Oxidation Processes (AOPs) as a pretreatment to enhance the toxicity and biodegradability of wastewaters was examined in several studies (Lafi, et al., 2009; Martin et al., 2010).

The high potential and effectiveness of AOPs for the total oxidation of hazardous organic compounds is widely recognized. The operation costs of these processes are, however, relatively high compared to those of biological treatment. Several studies (Scott and Ollis, 1995; Tabrizi and Mehrvar, 2004) demonstrated the synergetic effects of a combined chemical and aerobic oxidation. This combined treatment is based on the finding that many intermediates of the oxidation process are easily degradable in a further biological treatment. Hence, the pre-treatment system reduces the toxicity and increases the biodegradability of the effluent. For a considerable mineralisation, combined treatment requires less oxidant as compared to total chemical oxidation. The so-called partial chemical oxidation will therefore reduce operational cost.

Regarding the biological step, the effect of chemical pre-treatment on the properties of the effluent is usually assessed by means of biodegradability tests, toxicity tests, integrated studies where the partially treated effluent is fed to biological post-treatment (Mantzavinos and Psillakis, 2004). Monitoring the toxicity of complex effluents entering the biological treatment using bioassays could provide an early warning system to detect acute toxic events which can reduce the performance of the microorganisms (Dalzell et al., 2002).

In order to evaluate the impact of the toxic and biorefractory compounds on activated sludge plants, a method based on the detection of the bacterial activity is necessary. Respirometry is a very sensitive measurement and interpretation of the biological oxygen consumption rate under well defined experimental conditions (Spanjers et al., 1998). Oxygen consumption is directly associated with both biomass growth and substrate removal. In this study, a simple respirometric procedure was set up to detect effluent toxicity and to evaluate chemical pre-treatment. This method was taken because the mircroorganisms are representative for the wastewater treatment biomass.

Initially, the EC50 value of 3,5-dichlorophenol and 2,4-Dichlorophenol is measured. Further, synthetic wastewater, containing the previous mentioned xenobiotic compounds, is treated with ozone to enhance the toxicity level of the wastewater.

Material and Methods

The respirometric set up is based on the OECD method 209. The original procedure is adjusted according to Ricco et al. (2004). The respiration rate of the biomass is evaluated by the oxygen concentration profile detected in the liquid phase. Sodium acetate is utilized as a reference substrate. In the first step of the procedure, sodium acetate is added to the biomass and the maximum specific oxygen uptake rate (SOUR) value is measured when the oxygen supply is turned off. From the oxygen depletion profile, the respiration rate is measured. The same experimental procedure is followed to evaluate the maximum respiration rate in the sample. In this case, both the toxic compound to be tested and the sodium acetate were injected into the respirometer. The new SOUR value is utilized for toxicity evaluation. In the proposed procedure, the reference substrate and a series of increasing toxicant concentrations were tested.

Results and Conclusions

The inhibition percentages curve for 3,5-dichlorophenol obtained for three replicates are shown in Figure 1.1. The curves obtained are S-shaped, thus corresponding to a normal distribution of the microorganism respiration activity response to the variation of the toxic concentration (Ricco et al., 2004). An EC_{50} value of approximately 25 mg/l can be derived from the experimental results. Compared to EC_{50} values reported in literature, e.g. 11 mg/l (Elpabarawy et al., 1988) and 20 mg/l (Yoshioka and Sato, 1986), the toxicity data obtained in this study is significant higher, however, the same order of magnitude is obtained.

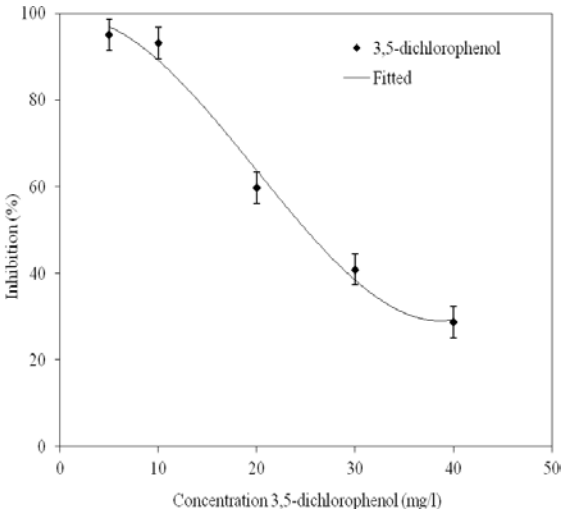

Figure 1.1 Inhibition percentage curve for 3,5-DCP

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