Evaluation of tertiary process of a biologically treated fungicide-based wastewater

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Abstract

Biologically-treated fungicide-contaminated wastewaters can be subjected to tertiary filtration treatment to meet the discharge limits. In this work, the tertiary treatment of a biologically-treated fungicide-based wastewater containing fludioxonil and imazalil was carried out through sand filtration and activated carbon sorption. The filtrates obtained were analysed via determination of their physicochemical characteristics, residual fungicide traces and toxicity tests. The sand column had slightly effect on removing organic residues (17% COD removal efficiency) from the biologically-treated wastewater. On the other hand, the activated carbon column resulted in high removal efficiencies, which were greater than 75% COD. Finally, toxicity tests were performed to assess the detoxification induced by the application of sand filtration and activated carbon sorption.

Keywords: *activated carbon sorption; sand filtration; detoxification; toxicity tests*

1. INTRODUCTION

Tertiary treatment processes are commonly used after secondary wastewater treatment to further improve the effluent quality and to be safely discharged or reused [1,2]. Tertiary treatment methods include physical (e.g. reverse osmosis; nanofiltration (NF)/ultrafiltration (UF); sand filtration; activated carbon sorption) and/or chemical processes (e.g. coagulation; TiO_2-photocatalysis; ozonation; other disinfection and advanced oxidation methods) [3]. More attention in recent years has been given in sand filtration for physical tertiary wastewater treatment [4]. The most important benefit of this kind of filtration is the effective removal of suspended solids. Many researchers have also proved that slow filtration of effluents through sand is more effective in removing suspended solids [5]. The main advantages of the sand filters are their low capital and operating cost and the easiness and simplicity in handling and maintenance.

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Over the last decades, activated carbon adsorption has been widely used in the tertiary treatment of wastewaters, resulting in obtaining high quality effluent by effectively removing residual organic carbon [6,7,8]. The advantages of activated carbon filter technologies are the high active surface and porous structure of activated carbon and its adsorption capacity for a wide range of pollutants [9]. Activated carbon can remove low molar mass pollutants (< 300 Da), metals, phenols, aromatic hydrocarbons, pharmaceuticals and pesticides [10,11]. Crini et al. [10] reported removal efficiencies of triazole fungicides greater than 99% through filtration in both powder and granular activated carbon. The granular activated carbon is the most commonly used activated carbon for tertiary treatment and effluent purification of municipal and industrial wastewater treatment plants. To determine the volume of water treated, the specific sorption capacity of a particular activated carbon type must be quantified [12].

The scope of this study was to evaluate the performance of two filtration systems, i.e. sand and activated carbon adsorption, regarding the tertiary process of a biologically-treated fungicides-containing wastewater.

2. MATERIALS AND METHODS

A sand column and an activated carbon column of 5 L working volume each were installed and operated in series for the tertiary process of a biologically treated wastewater containing fludioxonil and imazalil. The sand and activated carbon columns were cylindrical and made by opaque plexiglass columns. Their dimensions were equal, having each 14 cm internal diameter and 30 cm usable height. The sand filter consisted of 4 cm gravel on the bottom and 26 cm of quartz sand above gravel layer. The activated carbon column was filled successively from the bottom to the top with gravel (4 cm in height), quartz sand (3 cm in height) and granular activated carbon (23 cm in height). The laboratory-scale filters are presented in Figure 1.

Figure 1._The installed laboratory-scale sand and activated carbon filter systems._

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The sand and activated carbon were washed with distilled water prior to the filtration of the biologically treated wastewater through the respective columns. To evaluate the performance of tertiary filtration processes, all physicochemical parameters examined were determined according to the "Standard Methods for the Examination of Water and Wastewater" [13]. In brief, pH and electrical conductivity (EC) were determined by using a Hanna HI 98191 pH meter and a Crison CM35 conductivity meter, respectively. NH_4^+-N concentration was performed by employing steam distillation, whereas nitrate and nitrites were estimated through filtration in a Cd-copperized column and colorimetric estimation of the absorbance at 453 nm by using a sulfanilamide/(1-naphthyl) ethylenediamine-dihydrochloride indicator [13]. The sand filter was fed with biologically-treated wastewater derived from the effluent of an immobilized cell bioreactor, while the activated carbon filter was fed with the filtrate obtained from the sand column.

Phytotoxicity tests were carried out in the biologically treated effluent and in the permeates of sand and activated carbon columns by using organic tomato seeds incubated for five days at 25 ^oC in Petri dishes.

3. RESULTS AND DISCUSSION

The main physicochemical characteristics of biologically-treated fungicide-based wastewater were as follows: total COD, 209 mg/L; soluble COD, 181 mg/L; BOD_5, 1 mg/L; pH, 6.75; EC, 4.06 mS/cm; TDS, 219 mg/L; and NH_4^+-N, 1.77 mg/L. Moreover, no nitrates and nitrites were detected.

In the permeate of the sand and activated carbon filters, the total COD concentrations were 179 mg/L and 45 mg/L, respectively, while the respective soluble COD concentrations were 147 mg/L and 19 mg/L. The COD removal efficiency of the sand and activated carbon tertiary process during treatment of the biologically-treated fungicides-containing wastewater is presented in Figure 2. It is clear that the highest COD removal efficiencies were observed during application of the effluent in the activated carbon column. Similar to our study, the effectiveness of activated carbon to retain triazole fungicides has been previously reported [10,11]. The electrical conductivity was also reduced from 4.1 to 3.2 mS/cm after activated carbon filtration, whereas the sand filtration had no significant effect on EC. Influent and effluent pH values of sand filter were stable at 6.8, while the pH of the filtrate was increased at 7.2 after the activated carbon column.

Moreover, NH_4^+-N concentration in the permeate of the activated carbon filter was below 1 mg/L. A significant decrease ($p<0.05$) in the phytotoxicity was observed prior and after the tertiary process applied to further clean the biologically treated fungicide-based effluent.

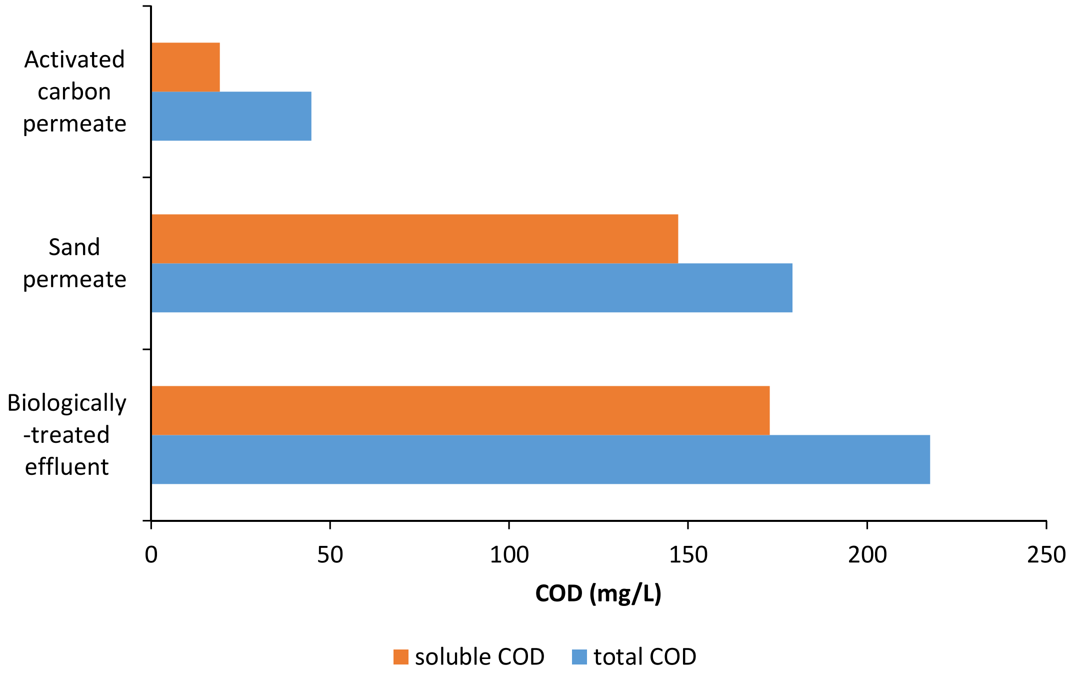

Figure 2. *COD removal prior and after sand and activated carbon filtration during tertiary process of a biologically-treated fungicides-containing wastewater.*

4. CONCLUSIONS

The application of two stages tertiary process of the biologically-treated fungicides-containing wastewater resulted in effective removal of COD in the permeate at the end of the physical processes, where activated carbon filtration highly reduced phytotoxicity index, suggesting that both sand and activated carbon filtration can effectively be applied for the post-treatment of biologically-treated fungicides-containing wastewaters.

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