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Optimization of continuous reactor at pilot scale for olive-oil mill wastewater treatment by Fenton-like process

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HIGHLIGHTS

- OMW reclamation from two-phase process was carried out in a CSTR by Fenton system.
- The optimum $[FeCl_3]/[H_2O_2]$ ratio was in the range 0.026–0.058 w/w.
- $[Fe^{3+}] = 0.35–0.40\ g\ dm^{-3}$ is necessary to achieve a higher COD removal (>97%).
- Water treated can be used for irrigation or discharged into urban wastewater system.

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ABSTRACT

Reclamation of olive-oil mill wastewater (OMW) from two-phase extraction procedure was carried out in a continuous stirred tank reactor (CSTR) at a pilot plant scale by Fenton-like process. The effect of operating conditions such as pH, space–time, H_2O_2 and Fe(III) doses, as well as $[FeCl_3]/[H_2O_2]$ ratio on the efficacy of Fenton's process was investigated. It is demonstrated that Fenton's process can effectively degrade organic matter in OMW. In the start-up stage, Fenton reaction reached steady state within 3 h. Oxidation of organic materials in OMW was pH dependent and the optimal pH was found to be 3. The optimum $[FeCl_3]/[H_2O_2]$ ratio was in the range 0.026–0.058 w/w, with Fe(III) concentration between 0.35 and 0.40 $g\ dm^{-3}$. The final values of COD and total phenols at the outlet of the pilot plant were close to 129 $mg\ O_2\ L^{-1}$ ($[COD]_{initial} = 4017\ mg\ O_2\ dm^{-3}$), and 0.5 $mg\ dm^{-3}$ ($[total\ phenols]_{initial} = 66.2\ mg\ dm^{-3}$), respectively. Finally, the produced water can be used for irrigation or discharged directly into the municipal wastewater system for ulterior tertiary treatment.

1. Introduction

Olive-oil mill wastewater (OMW) poses a serious environmental problem in the Mediterranean basin and concretely in the southern European countries like Spain, Italy, Greece and Portugal, where most part of the world olive oil is produced [1]. OMW effluents are well known by their seasonality and toxic character due to the presence of phenolic compounds, which are not suitable to be biologically managed [2]. Within this context, the application of chemical remediation strategies is required either to fulfil legislative requirements for direct disposal into the surroundings or, when economically wiser, to reduce toxicity and improve biodegradability to allow a posterior inexpensive bioprocess [3]. For these reasons, attention will be paid not only to chemical degradation parameters (such as chemical oxygen demand COD) but also to effluent's toxicity and biodegradable character (phenolic-compounds) [4].

Advanced oxidation processes (AOPs) are known for their capability to mineralise a wide range of organic compounds. AOPs involve the generation of highly reactive radical species, mainly hydroxyl radical [5]. AOPs' versatility is enhanced by the fact that there are many different ways of producing hydroxyl radicals. Heterogeneous photocatalysis using titanium dioxide (TiO_2) and solar UV, possibly combined with hydrogen peroxide (H_2O_2), and homogeneous processes such as Fenton (Fe^{2+}/H_2O_2) and photo-Fenton ($Fe^{2+}/H_2O_2/UV$) reactions have been proved to be useful tools for the treatment of pesticide-containing wastewaters [6]. Among AOPs, Fenton and solar photo-Fenton are known within the scientific community for their effectiveness to treat wastewater with high phenols content, such as that from the cork manufacturing [7], olive oil [3,8], winery [9] and pulp and paper industries [10].

The advantages of the Fenton's reagents are the high efficiency, simplicity, the lack of residues and capacity to treat many different compounds. In addition, it can be used as a pre-treatment stage be-

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