Printing ink wastewater treatment using electrocoagulation

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Abstract

Packaging paper wastewaters, stemming mainly from the dyeing sector of the production process (where printing inks are utilized), are characterized by large concentrations of organic matter, deep, strong color and almost zero biodegradability factor. These attributes, in combination with the presence of some toxic compounds (heavy metals, VOCs etc.) make further treatment necessary, before releasing the wastewater to the environment.

The present study deals with the treatment of these effluents using Electrocoagulation (EC). During the EC process, metallic species are electrochemically dissolved in the wastewater solution, resulting in coagulation, flocculation and subsequent separation of the pollutants *via* flotation or sedimentation. The efficiency of this method was evaluated, by examining the organic matter removal and decolorization of the wastewater under a wide range of operating parameters (current density, initial pH and electrode material). Moreover, the physical and chemical phenomena taking place during the process, as well its environmental footprint were investigated.

It was observed that this process is efficient under most of the operating conditions used, as the chemical oxygen demand removal ranged between 65 and 85 % and all the experiments managed high color removal, ranging between 98 - 100%. Additionally, secondary pollution was minimized, as concentrations of soluble metallic species remained below the regulated limits.

Keywords: printing ink wastewater; electrocoagulation; chemical oxygen demand; color

1. Introduction

Printing ink wastewater is generated from the cleaning process of the industrial printing equipment (such as flexographic presses) used in various industrial plants (textile, plastics, cardboard industries etc.) *(Pei and Yu, 2016)*. It consists of pigments, adhesives, trace quantities of heavy metals (e.g. Hg, Cd) and is mostly non-biodegradable *(Boguniewicz-Zabłocka,2016)*. These wastewaters are characterized by high concentrations of chemical oxygen demand (COD) (up to 20000 mg/L) and strong color *(Ding et al., 2011)*.

The characteristics mentioned above make biological treatment difficult to implement *(Zhang et al., 2003)*. Therefore, conventional physicochemical methods, such as chemical coagulation - sedimentation, are mostly used *(Pei and Yu,2016)*. Also, electrochemical methods and advanced oxidation processes have been used for the treatment of printing ink wastewater, either individually or coupled with other physicochemical methods *(Liu et al., 2016)*.

Electrocoagulation (EC), which is investigated in this study, is an electrochemical method used in wastewater treatment. In the EC process, coagulant species are generated *in situ* by electrodissoluted anods, usually aluminum or iron *(Hakizimana et al., 2017)*. Its reduced operating cost and the low amount of sludge it produces make EC an appealing treatment method for an extensive range of agro-industrial wastewaters *(Fernandes et al., 2015; Kuokkanen et al.,2013)*. This particular study investigates the treatment of printing ink wastewater originating from a printed corrugated box manufacturing plant. Different initial pH values (5,6,7,8), electrode types (Al, Fe) and current densities were applied (20.83, 41.67 and 83.33 mA/cm^2) to optimize COD and color removal.

2. Materials & Methods

2.1. Characterization of wastewater

The printing ink effluent was collected from a wastewater homgenizing tank of a local corrugated board packaging factory located in southern-central Greece. The factory produces approximately 20 m^3 of wastewater on a daily basis. The values of COD, Conductivity, pH, and total suspended solids (TSS) of the samples were determined at approximately 10000 ± 2300 mg/L, 5000 ± 1500 μS/cm, 7 and 10000 ± 1200 mg/L respectively. The color of the wastewater was black.

2.1. Experimental apparatus & methods

The experimental procedure was carried out in a batch, 0.5 L reactor with two aluminum (Al(−)/Al(+)) or two iron (Fe(−)/Fe(+)) electrodes (anode and cathode with 12 cm^2 area, spacing 3 mm) under magnetic stirring. he electrodes were connectedin monopolar parallel mode to a DC regulated power supply (model QJ3005C). COD was determined by the closed reflux dichromate method ac-cording to the Standard Methods *(APHA et al., 2012)* using a Waste-water Treatment Photometer (HANNA HI 83214). The extent of decolorization after electrocoagulation treatment was assessed by measuring the absorbance at 565 nm which was obtained by scanning the samples (DR 5000 spectrophotometer, Langehach).

3. Results

In general, COD removal reached a level of of 78%, while the color removal obtained reached 98% and above for all parameters tested. In particular, higher current density values resulted in more rapid pollutant removal (Fig.1a). However, the operating cost proved to be much higher under these conditions. As far as the electrode material is concerned, iron electrode produced similar results to the aluminum ones, in terms of pollutant removal. However, despite the lower operating cost they showed, the effluents treated with iron electrodes appeared yellowish, in comparison with the aluminum-treated ones, which were clear and transparent (Fig. 1c). Moreover, EC treatment proved to be very sensitive to pH changes, as at lower pH values (6 and 7), rapid coagulation was observed during the early stages of the process (Fig.1b). This could be attributed to isoelectric point coagulation. It is worth mentioning that, under the pH conditions used, Al and Fe are at their least soluble form, thus secondary pollution by the coagulants was minimized *(Hakizimana et al., 2017)*. Operating cost ranged between 0.59-2.54 €/m^3 proving that EC can prove to be a viable method for treating that particular wastewater.

4. Conclusions

Electrocoagulation (EC) was evaluated as a treatment method for printing ink wastewater (~75% COD removal,~99% color removal). It proved to be effective in terms of pollutant removal under most of the conditions examined, whilst avoiding significant secondary pollution.

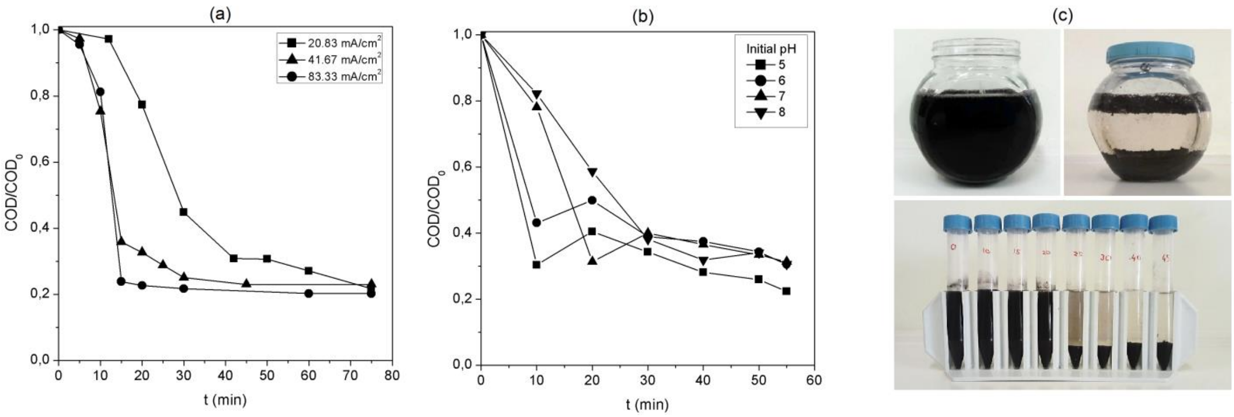

Figure 1. (a) Effect of current density on COD removal using Al electrodes, (b) Effect of initial pH on COD removal using Al electrodes, (c) Decolorization during the EC process (Al electrodes)

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