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The Use of Activated Carbon from Olive Oil Mill Residue, for the Removal of Colour from Textile Wastewater

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Abstract: Many human-made organic chemical compounds are currently possible to be detected in drinking water sources, hence, they are of increasing interest, because of their potential toxicity, carcinogenicity and mutagenicity effects. Among them, dyes from textile processing wastewater can enter in drinking water supplies. In this study, biologically treated textile wastewater, treated by activated carbon made from solved extracted olive pulp residue and olive wooden stone. Since these are waste materials, their use in the synthesis of activated carbon production process will reduce solid waste pollution. The results show that the COD of textile wastewater reduced for about 74%, as well as the TOC removal efficiency was 72%. Additional a maximum 84% remove of color was achieved by using 800 mg/L powder activated carbon dosage. These activated carbons were proved to be efficient adsorbents for the removal of water pollutants and contaminants

Key words: activated carbon, textile wastewater, solvent extracted olive pulp, adsorption

1. INTRODUCTION

Synthetic dyes are used extensively for textile dyeing, printing in industries and color photography and as additives in petroleum products. Over $7x10^5$ tons and approximately 10000 different types of dyes and pigments are produced worldwide annually. It is estimated that 10 to 15% of the dye is lost in the effluent during the dyeing process (Young and Jian, 1997; Danis et al., 1998).

Textile dye and finishing process are among the major industrial water users; in many areas, this industry has the wastes most difficult to treat satisfactorily. Effluents discharged from dyeing industries are highly colored and they can be toxic to aquatic life in receiving waters (Lee et al., 1999; Kadirvelu et al., 2000a; Kadirvelu et al., 2003) and are characterized for by pH, temperature and COD and low biodegradability (Vlyssides *et al*., 2000). The characteristics and chemical compounds of a typical textile industry) are shown in Table 1(Vlyssides *et al*., 2000).

Dyeing wastewaters are usually treated by conventional methods such as biological oxidation (Paprowicz and Slodczyk, 1988), adsorption (McKay, 1989) or coagulation by aluminum or iron salts (Hamza and Hamoda, 1980) Increasingly stringent legislation on the decontamination of wastewater has created on interest concerning the use of activated carbons for this purpose. However, activated carbons are expensive and, therefore, their use may imply carrying out regeneration and reactivation procedures (Walker and Weatherley, 1998; Rozada et al., 2003).

Commercially available activated carbons are usually derived from natural materials such as wood or coal. Turkey and Greece are two of the olive oil producing countries in the world. The solvent extracted olive pulp is one of the main by-products, which are produced during the olive oil and olive seed production. The use of that matter for the activated carbon production and its application in the toxic wastewater treatment comprises an interesting and silver lining. Using of the activated carbon produced from the waste of the olive oil processing called as solvent extracted olive pulp may reduce solid waste pollution and also minimize the cost of activated carbon production. The objective of this study was the compare the activated carbons prepared from solvent extracted olive pulp for textile reactive azo dyes removal from aqueous streams.

Table 1. Characteristics of textile wastewater

Character	
Total suspended solids (TSS) (mg/l)	34
pH	11.82
BOD_5 (mg/l)	1540
COD (mg/l)	3325
TOC (mg/l)	1810
Total Kjeldahl nitrogen (TKN) (mg/l)	314
Chlorides (mg/l)	24200
ADMI color units	41530

2. MATERIAL AND METHODS

2.1 Properties of Powder Activated Carbon

Powdered activated carbons prepared by physical activation of olive wooden stone (OWS), and solvent extracted olive pulp (OWSR) were provided from the NAGREF (Institute of Technology of Agricultural Products, Greece). The activated carbons used in this study were prepared by the physical activation of OWS and OWSR with steam/nitrogen mixture as the activating agent. Temperatures of carbonization and activation were kept constant at 850^{o}C and 800^{o}C respectively. Surface area (B.E.T method) was 800m^2/g for OWSR and 700m^2/g for OWS. Micro and mesoporosity volumes were *Vmicro* = 0.22 cm^3/g and *Vmicro* = 0.35 cm^3/g for OWSR and *Vmicro* = 0.19 cm^3/g and *Vmicro* = 0.12 cm^3/g for OWS.

2.2 Treatment of Reactive Azo Dyes

Reactive azo dyes used in this study are Remazol Gelb 3RS (yellow), Remazol Rb133 (red) and Remazol Schwarz B133 (blue), that they used from textile processing factory. The removal of dyes was determined spectrophotometrically (Pharmacia Biotech, Novaspec II). The absorbance values of the dye, before and after treatment, were measured at their respective maximum wavelengths of 405nm for Remazol Gelb 3RS, 520nm for Remazol Rb133 and 585nm for Remazol Schwarz B133. Absorbance and dye concentration relationship was determined from the exponential equations.

Two different dye concentrations of 100 and 150 mg/L were tested in adsorption experiments. One to six g/L adsorbents were taken in a 100ml conical flask including aqueous solution of dyes and agitated at 150 rpm at 25^{o}C. The conical flasks were withdrawn at 24h and the supernatant was separated by centrifugation at 6000 rpm and was used for spectrophotometric analysis.

2.3 Treatment of Biologically treated textile wastewater

Effluent wastewater samples were taken from the outlet of a textile wastewater treatment plant with an initial COD of 64 mg/L and TOC = 40 mg/L. OWSR was added in three beakers as 200, 400 and 800 mg/L respectively and last beaker was used as control without addition of activated carbon and agitated at 150 rpm at 25^{o}C. The conical flasks were withdrawn at 24 h and the supernatant was separated by centrifugation at 6000 rpm and was used for further analysis. Equilibrium concentration for COD and colour absorbencies were obtained at the end of 20 minutes. The colour content was determined by measuring the absorbency at three different wavelengths (445, 540, and 660 nm) and taking the sum of the absorbencies (Olthof et al. 1976; Eckenfelder 1989). Then the absorbencies were converted to the unit of m^{-1} using Eq.(1) (Barlas 1999).

$$A = (A/d)xf \tag{1}$$

COD measurements were carried out according to procedure in Standard Methods (APHA, AWWA,1992), titrimetric method 5220 C. Total organic carbon analyses were carried out by using a DOHRMANN DC-190 High Temperature TOC analyzer.

3. RESULTS AND DISCUSSION

Results obtained for each adsorbate adsorption (q_e in mg of adsorbate/g of adsorbent) starting at different initial concentration in the equilibrium (c_e in mg of adsorbate/L of solution) were fit to two adsorption isotherm models; Langmuir and Freundlich. A least-square fitting procedure was followed to get each model characteristic parameters and the determination coefficient corresponding to Langmuir equation is based on a theoretical model and its linearized form is given in equation (2).

$$\frac{Ce}{q_e} = \frac{1}{ab} + \left(\frac{1}{a}\right)Ce \tag{2}$$

where a is a constant relative to the adsorptive capacity and b is a parameter related

However, the Freundlich equation (3) is an empirical model that considers heterogeneous adsorptive energies on the adsorbent surface.

$$Logq_e = LogK_F + \left(\frac{1}{n}\right)LogCe \tag{3}$$

where the K_F parameter is relative to the adsorption capacity and n makes references to the process intensity.

Freundlich adsorption isotherms for three dyes (yellow, red, blue) removal were presented in figure 1, 3 and 5 and the respective Langmuir isotherms were presented in figure 2, 4 and 6. Considering the values of the determination coefficient for the linear fit (r^2), it was observed that the experimental data were more suitable to the Langmuir model than the Freundlich model.

In biologically treated textile wastewater adsorption experiment, COD, TOC efficiencies and equilibrium adsorption isotherms for colour parameter (q_e =color removed per unit weight of OWSR, m^{-1}/ mg OWSR/L and Ce = equilibrium concentration of color in solution after adsorption, m^{-1}) were investigated using OSWR. The results of this experiment were illustrated in Table 2.

Maximum COD and TOC removal efficiency of 75% and 72% were achieved by using 800mg/L solvent extracted olive pulp dosage, respectively. Freundlich adsorption isotherms for 445, 540, 660 and total wavelengths (nm) are given in Figures 7, 8, 9, 10.

Considering the values of the determination coefficient for the linear fit (r^2), it was observed that the experimental data were more suitable to the Freundlich model than to the Langmuir model for colour removal in biologically treated wastewater (Table 3).

Table 2. Results of Adsorption by OWSR

Act. Carbon Dosages (mg/L)	COD (mg/L)	COD Removal Efficiency (%)	TOD (mg/L)	TOD Removal Efficiency (%)	pH
0	640	-	400	-	8.10
200	160	74	120	70	8.21
400	160	74	110	73	8.32
800	160	74	110	73	8.53

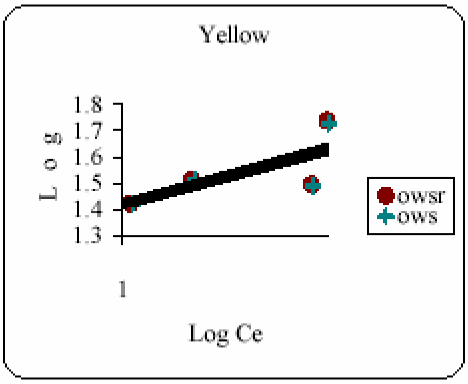

Figure 1. Freundlich isotherms for Yellow Color removal

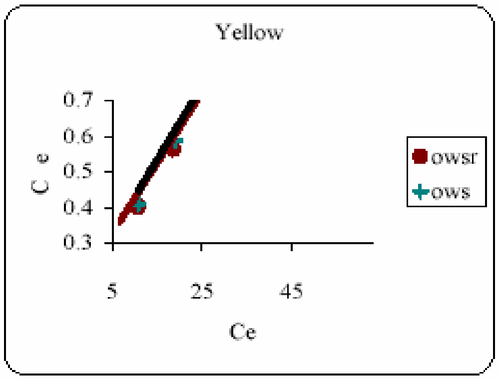

Figure 2. Langmuir isotherms for Yellow Color removal

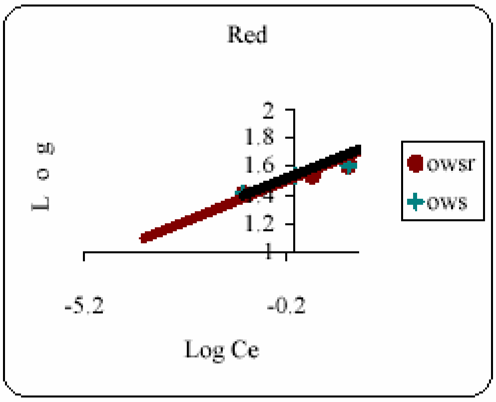

Figure 3. Freundlich isotherms for Red Color removal

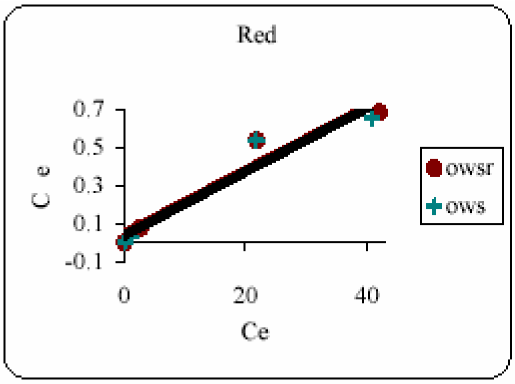

Figure 4. Langmuir isotherms for Red Color removal

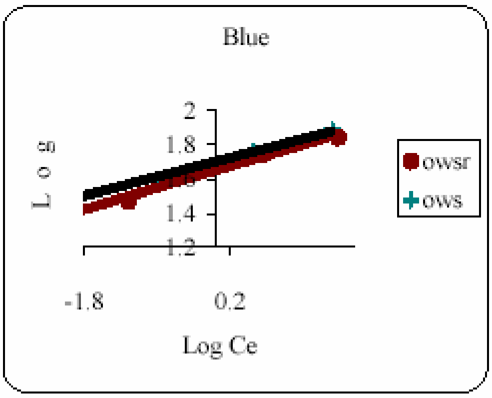

Figure 5. Freundlich isotherms for Blue Color removal

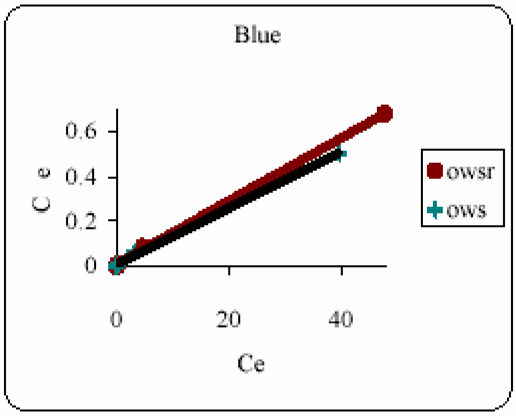

Figure 6. Langmuir isotherms for Blue Color removal

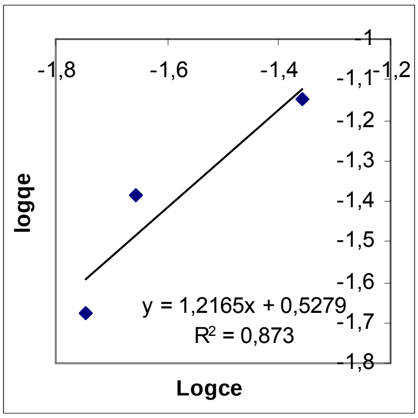

Figure 7. Freundlich isotherms for 445

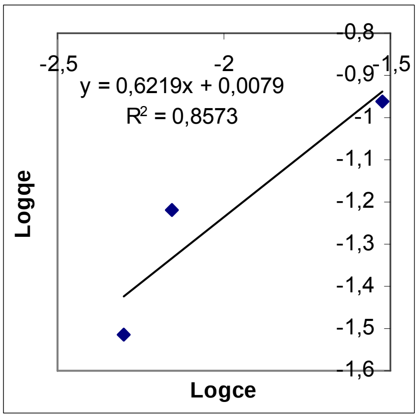

Figure 8. Freundlich isotherms for 540

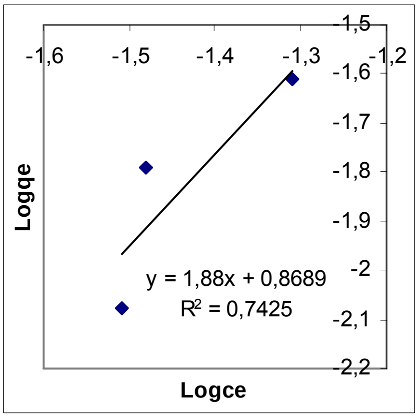

Figure 9. Freundlich isotherms for 660

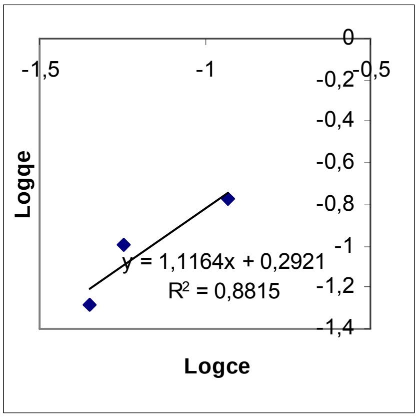

Figure 10 Freundlich isotherms for Total

Table 3. Results from fitting to Freundlich and Langmuir models

	Freundlich Isotherm			Langmuir Isotherm		
	Kf	1/n	R^2	a	b	R^2
Yellow	14.279	0.2683	0.528	50.00	0.089	0.734
Red	33.304	0.1147	0.842	59.88	0.350	0.935
Blue	44.565	0.1257	0.970	70.42	2.180	0.999
445	3.372	1.216	0.873			
540	3.353	0.622	0.857			
660	7.394	1.880	0.743			
Total	1.969	1.116	0.882			

The results of this study are promising to use the activated carbons produced from solvent extracted olive pulp that are abundant agricultural by-product of Mediterranean countries. The applying of this type of activated carbon is shown to have feasible and silver lining results in the treatment of toxic wastewater such as these of the textile industries.

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