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Research Article

COLOR AND COD REMOVAL FROM TREATED TEXTILE INDUSTRY EFFLUENTS WITH VARIOUS ADSORBENTS

Gül KAYKIOĞLU[1]*, Elçin GÜNEŞ[2,] Yalçın GÜNEŞ[3], Suna Özden ÇELİK[4]

[1]*Dep. of Environmental Engineering., Namik Kemal University, TEKIRDAG;* ORCID:0000-0003-3271-211X
[2]*Dep. of Environmental Engineering, Namik Kemal University, TEKIRDAG;* ORCID:0000-0002-1457-1504
[3]*Dep. of Environmental Engineering, Namik Kemal University, TEKIRDAG;* ORCID:0000-0001-8697-3345
[4]*Dep. of Environmental Engineering, Namik Kemal University, TEKIRDAG;* ORCID:0000-0001-9783-9512

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ABSTRACT

The rapid depletion and pollution of water resources are extremely negative impact on all life in Ergene River Basin in Turkey. The highly polluted sites were Corlu and Cerkezköy in the basin which located near the most urbanized and industrialized area. New discharge standards were developed by Turkish Water Pollution Control Regulation (TWPCR) for COD (chemical oxygen dimend) and color to prevent pollution caused by insufficient wastewater treatment in the basin. The aim of this study was to evaluate the color and COD removal efficiency of various adsorbents for biologically treated effluents of a local textile factory in Corlu which has COD:200 mg/L and color:39.4 m^{-1}. In the study four adsorbents were used: the waste metal hydroxide (WMH) obtained from aluminum electroplating industry, colemanite waste (CW) and ulexite waste (UW) collected from boron ore wastes and magnetic nanoparticles (Fe_3O_4) (MNP). The adsorption of color and COD onto different adsorbents were studied at natural pH (pH 7.5), different adsorbent doses (2-30 g/L) and different contact times (0, 15, 30, 60, 90, 120, 150, 180 min). The color removal efficiencies of WMH and UW were bigger than MNP and CW. Adsorption with UW achieved to equilibrium at 120 min and with WMH at 180 min. The maximum color removal efficiencies were 67% for UW and 57% for WMH. The maximum COD removal efficiencies were 72% for UW and 70% for WMH. Both adsorbents were reduced COD below 100 mg/L and color below 20 m^{-1}. Freundlich model yielded better fit than the Langmuir model for the adsorption of color and COD on UW and WMH.
Keywords: Adsorption, waste metal hyroxide, ulexite waste, colemanite waste, magnetic nanoparticles.

1. INTRODUCTION

Textile industry uses large amounts of water and generates high volumes of colored wastewaters. Dyeing and finishing processes used in textile industry are recognized as major source of colored effluents. Discharge of these wastewaters into streams poses a severe problem. Textile dyeing effluents are composed of complex mixtures of dyes and auxiliary chemicals, salts, acids, bases, organochlorinate d compounds, and heavy metals [1]. Traditional treatment methods such are generally ineffective for total color removal. Adsorption technique is one of the most powerful tool for the removal of various pollutants from the water and wastewater [2]. Especially

* Corresponding Author: e-mail: gkaykioglu@nku.edu.tr, tel: (282) 250 23 69

if low-cost waste materials such as waste metal hydroxide, coconut, eggshell, rice husk etc. were used adsorption technique may be very advantageous [3-5].

The aim of this study is to utilize various adsorbents. In the study four adsorbents were used: the waste metal hydroxide (WMH) obtained from aluminum electroplating industry, colemanite waste (CW) and ulexite waste (UW) collected from boron ore wastes and magnetic nanoparticles (Fe_3O_4) (MNP). These adsorbents were used for color and COD removal of biologically treated effluents of a local textile factory in Corlu.

2. MATERIAL AND METHODS

2.1. Preparation of Adsorbents

In this study four adsorbents were used: the waste metal hydroxide (WMH), colemanite waste (CW) and ulexite waste (UW) and magnetic nanoparticles (Fe_3O_4) (MNP).

WMH obtained from aluminum electroplating industry and was generated by alkaline precipitation of the metal ions present in wastewater. The sludge was dried at room temperature, ground, sieved and washed with distilled water several times. The powder of particle size smaller than 500 µm was used as the adsorbent [4].

Colemanite waste (CW) and ulexite waste (UW) collected from boron ore wastes and sieved with 1mm pore size sieve.

MNP was preparated as follow: 6.1 grams of $FeCl_3{\cdot}6H_2O$ and 4.2 grams of $FeSO_4{\cdot}7H_2O$ were dissolved in 100 mL of distilled water and heated up to 90 ^oC. 10 mL 26% of ammonium hydroxide in 200 mL of distilled water were added to each other quickly. The solution was mixed for 30 minutes at 80 ^oC and cooled down to room temperature. The obtained MNP was precipitated for 1-2 minutes and then washed with distilled water for 3 times. After that, separated MNP is dried at 50 ^oC [5, 6]. MNP has 62.99% Fe content.

2.2. Wastewater Origin

In this study, biologically treated effluents of a local textile factory in Corlu which has COD: 200 mg/L and color: 39.4 m^{-1} was studied.

2.3. Batch Adsorption Studies

The adsorption studies were carried out at different adsorbent concentrations (2-30 g/L) to investigate the adsorptive capacity of the adsorbent. The adsorption of color and COD onto different adsorbents were studied at natural pH (pH 7.5), different adsorbent doses (2-30 g/L) and different contact times (0, 15, 30, 60, 90, 120, 150, 180 min). COD and color removal were studied by a series of equilibrium experiments. The contents of each flask were centrifuged at 3500 rpm for 5 min and COD and color were measured in the supernatant. The samples were taken at the end of the desired contact time to determine the effect of agitation time. The flasks were agitated at room temperature (25^oC) at 200 rpm.

The amount of color and COD adsorbed were calculated from the following equation (1):

$$q_e=V(C_o-C_e)/W \tag{1}$$

where qe is the amount adsorbed (mg/g); Co and Ce are the initial and equilibrium color COD concentrations in the solution (mg/L), respectively; V is the solution volume (L); and W is the mass of adsorbent (g).

2.4. Analysis

The color (m^{-1}) was measured according to EN ISO 7887 color measurement method and chemical oxygen demand (COD, mg/L) determined according to standard methods [7].

3. RESULTS AND DISCUSSION

3.1. Removal Rates of COD and Color

The color removal efficiencies by WMH, MNP, UW, and CW at different contact times are shown in Figure 1 and Figure 2. As shown from the Figure 1 and Figure 2 that color removal efficiencies of WMH and UW were bigger than MNP and CW. So CW and MNP were not used in the further studies. As it can be seen from Figure 1 color removal efficiencies increased with increase of contact time. As seen from Figure 1 UW reached equilibrium at 120 min and WMH didn't reach at 120 min and WMH achieved to equilibrium at 180 min (Figure 3).

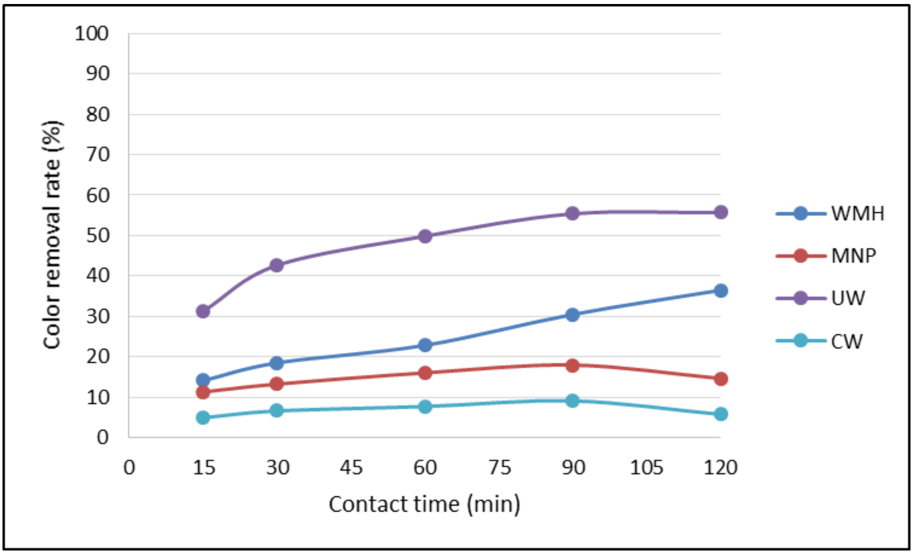

Figure 1. Effect of contact time of various adsorbents on color removal efficiency

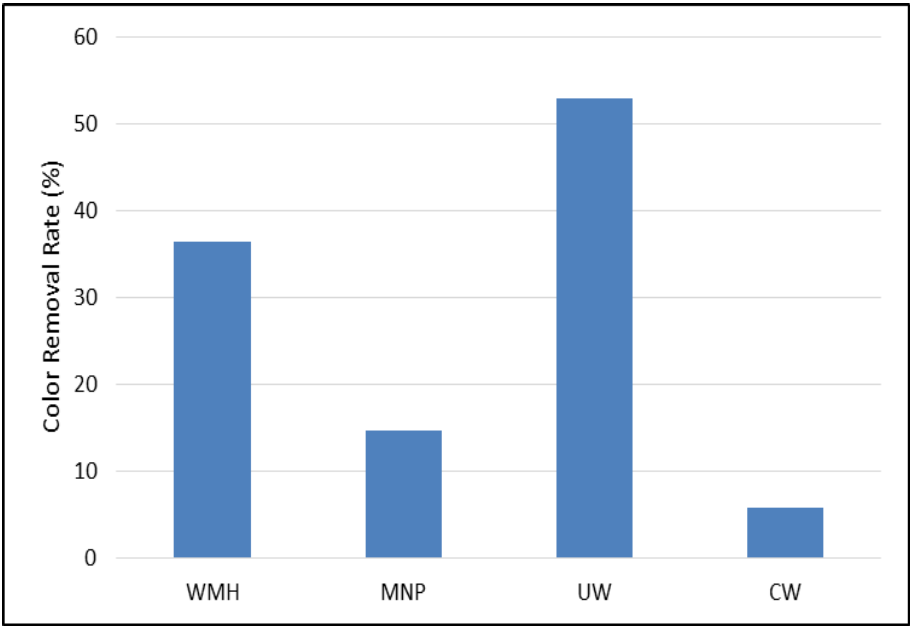

Figure 2. Comparing color removal efficiency of adsorbents at 120 min.

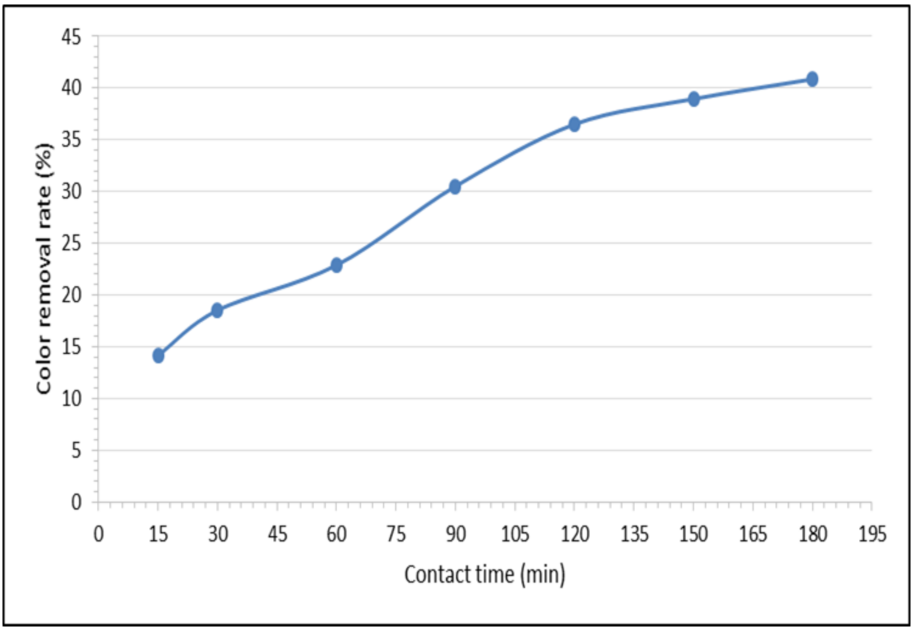

Figure 3. Effect of contact time on color removal efficiency for WMH

Removal efficiency of COD and color is highly affected by adsorbent concentration. Raising the WMH and UW doses from 2 g/L to 30 g/L the COD removal efficiency increased from 23% to 70% and 45% to 72% respectively (Figure 4). As it can be seen from Figure 4 that COD removal achieves to equilibrium at 30 g/L for WMH and at 20 g/L for UW. At equilibrium point Ce values were 60 mg/L for WMH and 54 mg/L for UW.

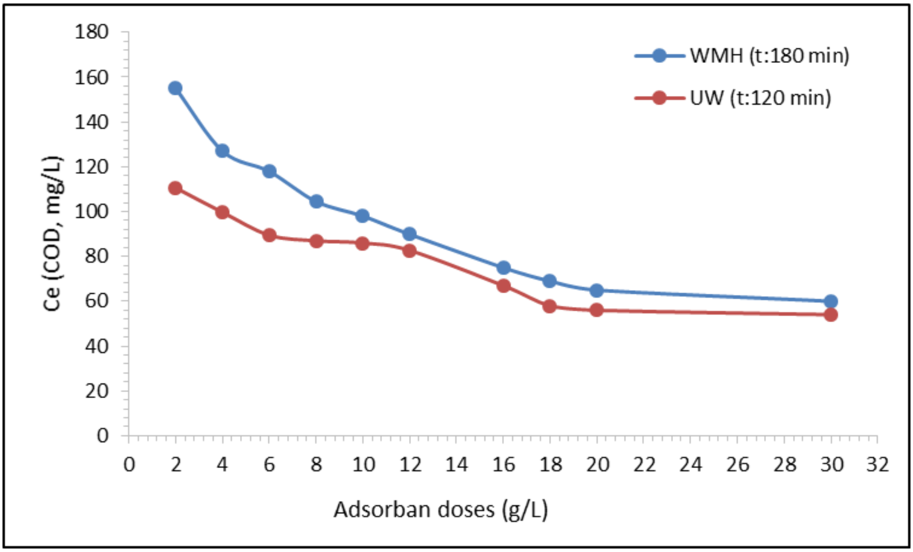

Figure 4. Equilibrium COD concentrations obtained for WMH and UW at different doses

Raising the WMH and UW doses from 2 g/L to 30 g/L the color removal efficiency increased from 22% to 57% and 40% to 68%, respectively (Fig.5). Color removal achieves to equilibrium at 20 g/L for WMH and at 18 g/L for UW. At equilibrium point Ce values were 17.4 m^{-1} for WMH and 12.3 m^{-1} for UW.

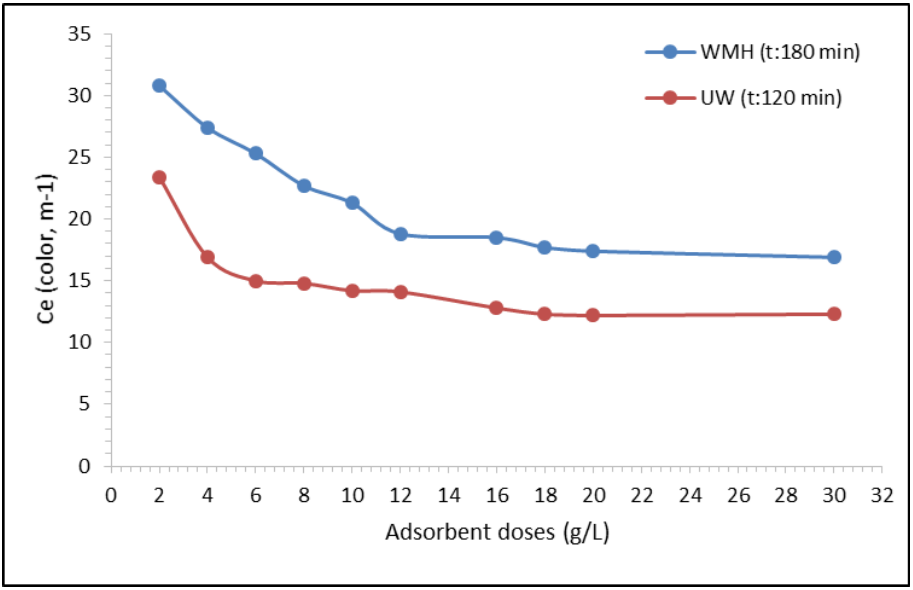

Figure 5. Equilibrium color concentrations obtained for WMH and UW at different doses

3.2. Adsorption equilibrium study

Two isotherm models (Freundlich and Langmuir) were used in the present study to describe the adsorption data (Table 1).

Table 1. Models used to describe the adsorption of COD and color

Freundlich	$q_e = K_F {C_e}^{1/n}$	K_F is a constant depicting adsorption capacity, $1/n$ is a constant indicating adsorption intensity.
Langmuir	$_e = C_e K_L q_m + q_m$	K_L (L g^{-1}) represent s the Langmuir constant and q_m (mg g^{-1}) is the maximum adsorption capacity for monolayer formation on adsorbent

It was found from the results that only the Freundlich isotherm model described and predicted COD and color adsorption on UW and WMH (Table 2). Values of the adsorption intensities (1/n) less than 1 show the favorable nature of adsorption on the adsorbents [8, 9]. As it is seen from Table 2 that the adsorption intensities are found higher than 1. If $1/n$ value is high it shows that the adsorbent used will lose its capacity more rapidly than the others [10]. So $1/n$ values found in this study show that these adsorbents will lose their capacity rapidly.

Table 2. Isotherm constants for the Freundlich isotherm

Parameters	Freundlich constants					
	UW			WMH		
	K_F	1/n	R^2	K_F	1/n	R^2
COD	$4.5.10^{-4}$	2.36	0.8454	0.0118	1.49	0.9633
Color	$5.6.10^{-4}$	3.12	0.8425	0.0014	2.32	0.9179

Table 3 gives the COD removal rates for adsorption on various adsorbents obtained from this study and obtained in other studies. As it is seen from the Table 3 that WMH and UW could be used as low cost adsorbents to remove COD from biologically treated effluents and the new methods could be tested to increase COD and color removal efficiency by these adsorbents.

Table 3. COD removal rates for adsorption on various adsorbents

Adsorbent	Wastewater	Initial COD concentration (mg/L)	Adsorbent doses (g/L)	COD Removal rate (%)	Reference
Coconut shell carbon	Industrial	553	40	46-71	[10]
Rice husk carbon	Industrial	553	40	45-73	[10]
Fly ash	Domestic	1080	40	88	[11]
Brick kiln ash	Domestic	1080	60	83	[11]
Ulexite waste	Textile eff.	200	20	71	This study
Waste metal hydroxide	Textile eff.	200	30	68	This study

3. CONCLUSION

In the study various adsorbents; the waste metal hydroxide (WMH) obtained from aluminum electroplating industry, colemanite waste (CW) and ulexite waste (UW) collected from boron ore wastes and magnetic nanoparticles (Fe_3O_4) (MNP) were used as adsorbent for color and COD removal of biologically treated textile industry effluents. Color removal efficiencies of WMH and UW were bigger than MNP and CW. The influence of agitation time and adsorbent dose on the removal of COD and color in aqueous solution by WMH and UW were evaluated. The removal efficiencies of COD and color increased with increase in agitation time. Adsorption with UW achieved to equilibrium at 120 min and with WMH at 180 min. The maximum color removal efficiencies were 67% for UW and 57% for WMH. The maximum COD removal efficiencies were 72% for UW and 70% for WMH. Both adsorbents were reduced COD below 100 mg/L and color below 20 m^{-1}. Freundlich model yielded better fit for the adsorption of color and COD on UW and WMH.

The results of adsorption study indicated that UW and WMH could be used as low cost adsorbents to remove COD and color from biologically treated effluents.

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