USE OF CONSTRUCTION AND DEMOLITION WASTE AS LOW COST ADSORBENTS FOR THE REMOVAL OF ACID BLUE113 FROM AQUEOUS SOLUTION

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ABSTRACT: Construction and demolition waste (C&DW) is available in abundance, which can be used in textile wastewater treatment. The present study was undertaken to evaluate the adsorption capacity of C&DW for the removal of AB113 from aqueous solution. The effect of contact time, pH, dosage of adsorbent and temperature was studied to determine the optimum experimental condition to increase the capacity of adsorption. The maximum adsorption capacity was obtained at optimum conditions (natural pH, S/L = 20 g L^{-1}, 20 °C).

Keywords: adsorption; Construction and demolition waste; textile wastewater treatment; thermodynamic.

1. INTRODUCTION

Construction and demolition waste (C&DW) is characterized by its high volume and weight, although its environmental impact is low when compared to other waste because most of the fractions are inert. The environmental impacts associated with a high amount of C&DW are mainly derived from its transport and occupation of large areas in landfill and natural resource depletion. The C&DW measured in volume, represents the largest waste stream in the EU and represents approximately one third of all waste produced, which is approximately 820 million tonnes every year produced (Gálvez-Martos et al., 2018) and without adequate management (López Ruiz et al., 2020). Therefore, C&DW management is an important focus of current European policies and in the circular economy package (Gálvez-Martos et al., 2018; López Ruiz et al., 2020; Sormunen & Kärki, 2019). In order to achieve the goals of EU, some practical management of C&DW was implanted. C&DW was used in different practices in geotechnical applications such as filler material for construction of roads and embankments (Vieira & Pereira, 2015).

The proposed research is aimed to purpose other application of C&DW at wastewater treatment. Adsorption has been proposed as an excellent alternative for wastewater treatment, which offers significant advantages, including its low economic cost, availability, profitability and ease of operation (Uddin, 2017). At present, multiple types of adsorbents are used, such as natural and industrial geo materials, waste materials from industry, agricultural by-products and active carbon to remove contaminants in wastewater (Yagub et al., 2014). All this entails the research of the efficient use of construction and demolition waste as a low cost adsorbent to replace the conventional adsorbents.

This study will address the application of C&DW as an adsorbent of dyes from textile industry wastewater such as acid blue 113. For this, batch experiments were conducted to study the influence of various influential adsorption parameters of dye such as contact time, solution pH, adsorbent dosage, and temperature.

2. Materials and methods

2.1 Adsorbent and dye solutions

Fine aggregates of construction and demolition waste (C&DW) were collected from a construction and demolition waste recovery company (Málaga, Spain). Initially recycled particles were sieving after receiving. Samples of particle size between 0.038 and 0.125 mm were used in further experiments.

Acid Bleu 113 dye [molecular formula = $C_{32}H_{21}N_5Na_2O_6S_2$, molecular weight = 681.65 g mol $^{-1}$; Colour Index Number 26360], was obtained from Sigma-Aldrich. The structure of the dye Acid Bleu 113 is shown in Figure 1. Stock solution of initial AB 113 dye concentration as 1000 mg L^{-1} was prepared by dissolving dye in deionized water. Stock solution was then diluted to prepare solutions of desired dye concentrations. The concentration of the AB 113 dye was determined at λ_{max} of 566 nm, using UV spectrophotometer (Shimadzu Model: UV 1280). Solution pH values were adjusted by appropriate addition of 0.1 M HNO_3 or NaOH solutions.

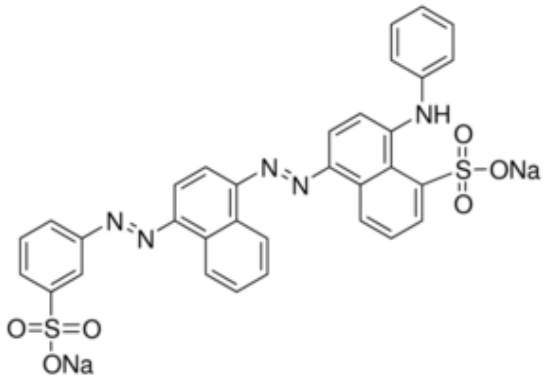

Figure 1. Chemical structure of the dye Acid Blue 113

2.2 Batch adsorption experiments

For each batch experiment, a known mass of adsorbent was immersed in 50 mL of dye solution for different contact times at 25 °C with continuous stirring on a rotary shaker at 200 rpm. The effect of temperature on the adsorption processes has been also evaluated at different temperatures ranged from 20 to 40 °C. The residual solution was filtrated before analysis by UV spectroscopy. Each essay was carried out by duplicate at the same controlled conditions to assure the reproducibility.

The capacity of adsorbed of dye and the percentage removal of dye was calculated using the following equations:

$$q = \frac{C_0 - C_f}{m} V \quad (1)$$

$$\%\ Colour\ removal = \frac{C_0 - C_f}{C_0} \cdot 100 \quad (2)$$

where q (mg g^{-1}) is the amount of adsorbed dye, C_0 (mg L^{-1}) is the dye concentration at the beginning, C_f (mg L^{-1}) is the dye concentration at the end, *V* (L) is volume of the dye solution and *m* (g) is the mass of the adsorbent.

The thermodynamic parameters as the Gibbs free energy (ΔG°), enthalpy (ΔH°) and the entropy (ΔS°), were obtained as:

$$\Delta G° = -R\ T\ lnk_D \quad (3)$$

$$Lnk_D = -\frac{\Delta H^{\circ}}{RT} + \frac{\Delta S^{\circ}}{R} \quad (4)$$

$$\Delta G^{\circ} = \Delta H^{\circ} - T\Delta S^{\circ} \quad (5)$$

where T (K) is the temperature and k_D is distribution coefficient. The values of ΔH° (J mol^{-1}) and ΔS° (J mol^{-1} K^{-1}) were obtained from the values of the slope and the intercept by plotting ln (k_D) versus 1/T.

3. RESULTS AND DISCUSSION

3.1 Effect of contact time and pH

The contact time and the pH value are the most relevant parameters influencing the adsorption processes. Figure 2 depicts the effect of contact time on adsorption of AB113 on C&DW. Results show that the dye removal increases rapidly and reaches almost 90 % for 100 mg L^{-1} in 1 h. As can be observed, the adsorption capacity (q) within 3 min attains more than 50% of the equilibrium adsorption capacity. The equilibrium time selected in this study was 3 h for further experiments in order to ensure the maximum adsorption of the dye.

Figure 3 illustrates the effect of pH on the adsorption of AB113 on C&DW. As can be seen, the adsorption capacity remained without important change at acid or neutral pH, but at alkaline medium, the adsorption capacity decreases due to the acidic character of AB113. In this study, the dye presents maximum adsorption capacity at natural pH of 6.5, and all experiments were carried out at natural pH of AB113 solution.

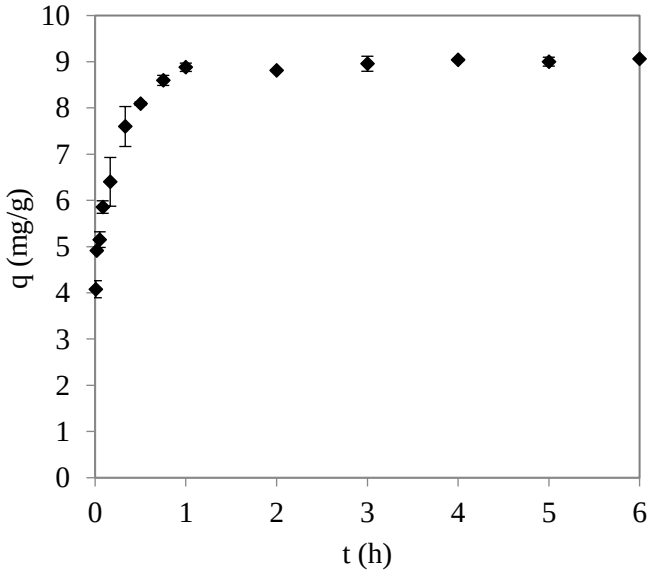

Figure 2. Effect of contact time on adsorption of AB113 on C&DW (natural pH; C_0 = 100 mg L^{-1}, S/L = 10 g L^{-1}).

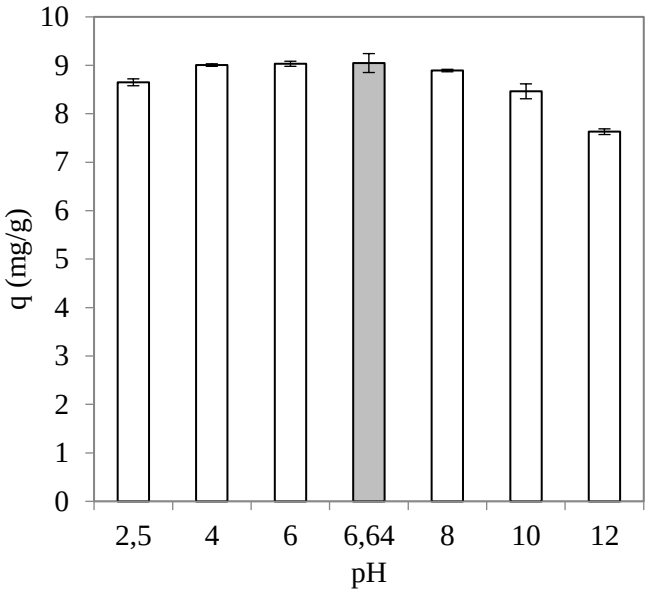

Figure 3 Effect of pH on adsorption capacity of AB113 by C&DW. (C_0 = 100 mg L^{-1}, S/L = 10 g L^{-1})

3.2 Effect of adsorbent dosage

The effect of adsorbent dose on the removal of dye was studied by varying the relation S/L from 1 to 100 g L^{-1}. Figure 4 shows the effect of adsorbent dosage on percentage removal of AB113. The adsorption of dye increases with an increase in adsorbent dosage due to the increase of active sites available for adsorption of the dye. As shown, when the adsorbent dosage was increased from 2 to 20 gL^{-1}, the removal of dye increases from 66 % to 96 %. This value remained without significant increase in dye removal when the adsorbent dosage was above than 20 g L^{-1}, which can be attributed to excess presence of active adsorption sites at high adsorbent dosage.

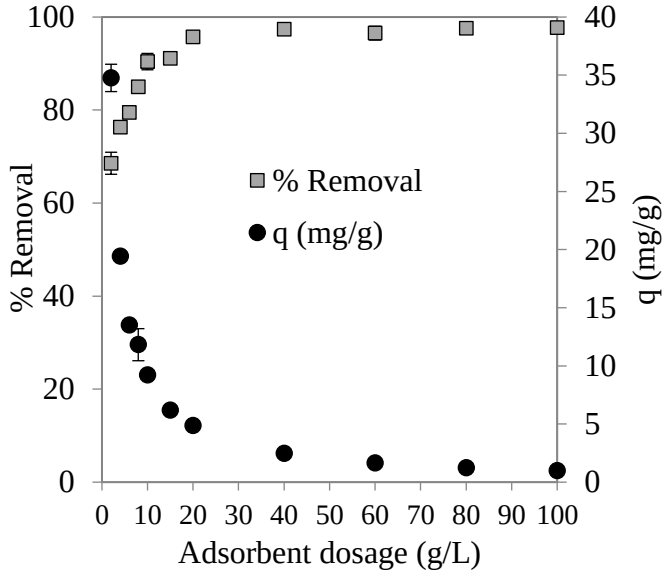

Figure 4. Effect of adsorbent dosage on percentage removal and adsorption capacity of AB113 by C&DW (C_0 = 100 mg L^{-1}, natural pH)

3.3 Effect of temperature

Adsorption capacity is considerably influenced by temperature. Table 1 shows the thermodynamic parameters that have been evaluated from the plot of ln K versus 1/T. The negative value of ΔG° indicates the feasibility and spontaneous nature of the adsorption of AB 113 dye on C&DW. The enthalpy (ΔH°) value has been found to be negative which indicates exothermic nature of the adsorption process. This is probably due to the decrease of the forces between the AB 113 dye and the active sites on the adsorbent surface (Yagub et al., 2014). These results are in line with some works in the literature (Deniz & Saygideger, 2011; Errais et al., 2011). On the other hand, the negative value of ΔS° implies the decreased randomness at the solid/solution interfaces during adsorption process.

Table 1. Thermodynamic parameters for adsorption of AB 113 on C&DW.

Temperature (K)	ΔG° (kJ mol^{-1})	ΔH° (kJ mol^{-1})	ΔS° (kJ mol^{-1} K^{-1})
294,75	-3,14	-48,70	-0,018
298,65	-2,85		
302,75	-2,15		
308,75	-1,06		
313,65	-0,36		

4. CONCLUSIONS

C&DW is an effective adsorbent for the removal of AB113 from aqueous solutions. Several parameters have showed direct effect on the adsorption capacity. The natural pH of the dye solution was selected as optimum value for the maximum removal of AB113. The removal capacity increased with an increase of dose of the adsorbent and decreased with the temperature increase. The thermodynamic parameters confirmed that the adsorption process is exothermic and spontaneous in nature. According to this results, the C&DW presents promising characteristics to be used a sustainable adsorbent for dye removal.

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