Advanced Engineering Days

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Adsorption of Astrazon red GTLN (AR) with volcanic tuff Bayburt Stone

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Cite this study: Kocadağistan, B., & Kocadağistan, E. (2021). Adsorption of Astrazon red GTLN (AR) with Volcanic Tuff Bayburt Stone. 1st Advanced Engineering Days, 60-62

Keywords
Adsorption
Volcanic tuff
Removal efficiency

ABSTRACT

Adsorption is a very effective, widespread, easy and inexpensive method used for textile dye removal from wastewater. Bayburt stone powders were used as adsorbent and Astrazon red GTLN textile dye was used as adsorbate. According to the results of the study, the optimum pH value was 10, the initial dye concentration was 10 mg/L, the mixing speed was 200 rpm and the adsorbent amount was 10 g/L. Langmuir, Freundlich and Temkin isotherms were used to evaluate the adsorption dynamics. Langmuir isotherm was best fit and Astrazon Red removal efficiency was found to be 85% by using Bayburt stone under optimum conditions.

Introduction

Along with industrialization, the textile industry is developing rapidly. Finishing processes such as dyeing, printing, washing and drying are commonly used in textile fabrics. Since textile dyes pollute the receiving water environment, they must be treated before being discharged [1]. For this purpose, various methods such as coagulation, flocculation, electrochemical processes, chemical oxidation, reverse osmosis, electrochemical filtration, aerobic and anaerobic treatment are used for dye removal. More economical and more suitable operating conditions are preferred in terms of the applicability and efficiency of the treatment methods used in dyestuff removal [2]. Akbal [3] investigated the adsorption of methylene blue dyestuff in aqueous solutions with pumice powder and revealed that adsorption increased as the amount of adsorbent and time increased, and the adsorption rate of basic dye decreased with increasing concentration. Adsorption studies are carried out by changing conditions such as different organic and inorganic materials and different pH, temperature, concentration, adsorbent amounts, and optimum conditions for adsorption are determined. Adsorption continues until a balance is established between the concentration of the substance deposited on the surface of the adsorbent and the concentration of the substance remaining in the solution. At this equilibrium moment, the relationship between the amount of substance adsorbed at constant temperature and the equilibrium pressure or concentration is called "adsorption isotherm" and gives information about the characterization of the experiment. Sawasdee et al. [4] used rice husk as an adsorbent material for dye removal from aqueous solution and observed that the adsorption process reached equilibrium at pH 7.87 and within 90 minutes.

Material and Method

The yellow Bayburt stone, which was used as an adsorbent in the study, was first cleaned by washing several times with the help of distilled water and left to dry in an oven at 105 °C for 24 hours and then ground into powder. In order to investigate the zeta potential values, potential measurements were made at different pH values between 2 and 12 and the maximum value was obtained at pH 10 as -29.8 mV. The chemical formula of Astrazon Red, the textile dye used in the study, is $C_{19}H_{25}ClN_5O_2$. Different inlet concentration, temperature and contact time values were tried to determine the optimum conditions. SEM photographs of Bayburt stone before and after adsorption are shown in Figure 1 and Figure 2. 1 N hydrochloric acid (HCl) and 1 N sodium hydroxide (NaOH) solution were used to bring the pH value to the desired values.

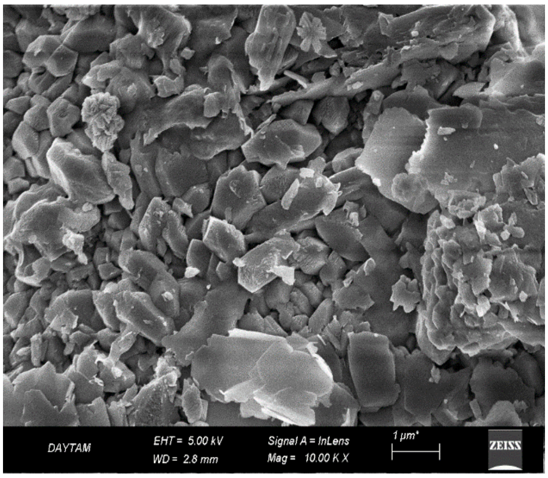

Figure 1. Before adsorption

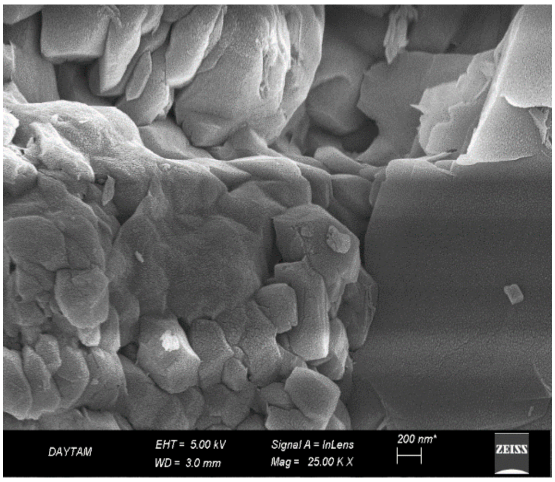

Figure 2. After adsorption

The equilibrium amount (qe) of adsorbed substances and removal efficiency was calculated with the following equations:

$$qe = \frac{Co - Ce}{m} . V \quad (1)$$

$$\%R = \frac{Co - Ce}{Ce} . 100 \quad (2)$$

where Co and Ce are the liquid-phase concentrations of dye (mg/L) at initial and equilibrium state, respectively, V is the volume of the solution (L) and m is the mass of dry sorbent(g) [5].

Results

The study was carried out at 25˚C, 30˚C, 35˚C conditions. According to the results of the adsorption study, it was determined that the highest dye removal efficiency was at 35˚C (Figure 3). The following experiments were carried out under different temperature and inlet concentration conditions and the dye removal efficiencies were investigated. It was observed that the adsorption efficiency decreased as the inlet concentration increased (Figure 4). In order to determine the adsorption efficiency and concentration change in the adsorption process, experiments were carried out up to 90 minutes and the first 30 minutes were found to be the effective time.

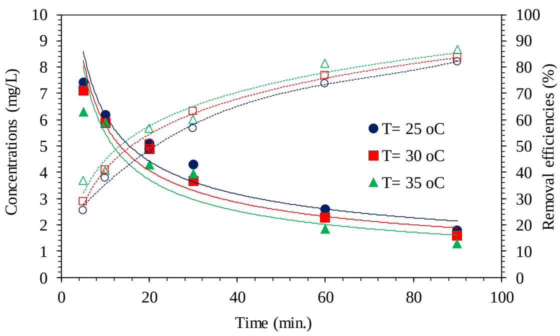

Figure 3. Concentrations with time for different temperatures

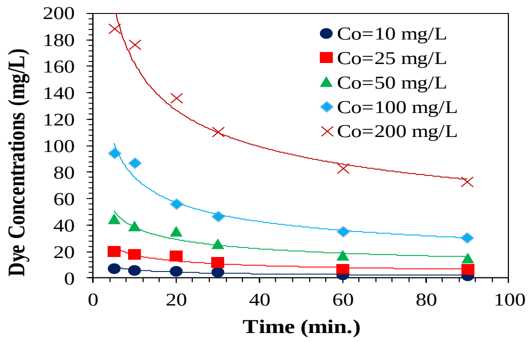

Figure 4. Concentrations with time for different initial dye concentrations

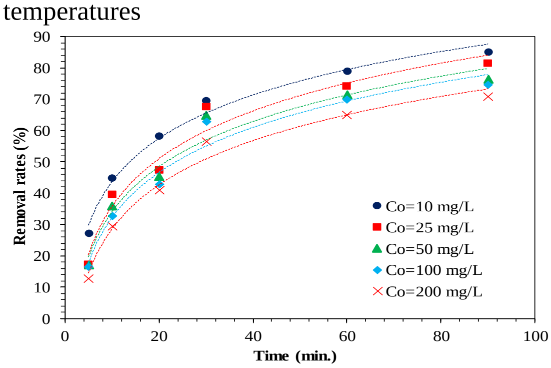

Figure 5. Removal rates for different initial dye concentrations

When the dye removal efficiency values were examined against different initial concentrations, as can be seen in Figure 5, the adsorption efficiency decreased as the concentration value increased.

Discussion

The results obtained in this study revealed that Bayburt stone, which is very cheap and easy to find, is an effective adsorbent material.

Conclusion

In order to determine the optimum dye concentration, experiments were carried out with concentrations of 10 mg/L, 25 mg/L, 50 mg/L, 100 mg/L and 200 mg/L. As the initial dye concentration increased, the removal efficiency decreased and the optimum value was determined as 25 mg/L. In addition, 1 g/L, 2 g/L, 5 g/L and 10 g/L adsorbent amounts were used to determine the most suitable adsorbent amount, and it was determined that 10 g/L adsorbent substance amount was the most appropriate. In the study; 85% adsorption efficiency was obtained by taking the temperature 35°C, inlet dye concentration 10 mg/L, stirring speed 200 rpm and adsorbent concentration 10 g/L. As a result, the results of the study showed that Bayburt stone is an economical, effective and suitable adsorbent that can be used in the adsorption method.

Author contributions:

Erdem Kocadağistan: Writing-Original drafting, Software, Validation. **Beyhan Kocadağistan**: Visualization, Analysis, Writing-Review and Editing.

Conflicts of interest:

The authors declare no conflicts of interest.

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