Available Online at http://www.journalajst.com

ISSN: 0976-3376

ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

Asian Journal of Science and Technology
Vol. 09, Issue, 07, pp.8399-8402, July, 2018

RESEARCH ARTICLE

DE-COLORIZATION OF REACTIVE DYE EFFLUENT USING CELLULOSIC ADSORBENT

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ARTICLE INFO

Article History:
Received 10th April, 2018
Received in revised form
21st May, 2018
Accepted 03rd June, 2018
Published online 30th July, 2018

Key words:

Bagasse, Adsorption,
Dyes, Reactive Blue S-R,
Textile effluent,
Color Removal.

ABSTRACT

Bagasse fly, a waste from the sugar industry which helps to investigated as a replacement for the current expensive other chemicals for the removal of reactive dyes from aqueous solutions. In this study, the de-colorization of industrial textile wastewaters was treated with bagasse fly as low-cost adsorbent. Bagasse was collected from a local sugar factory in Ethiopia and from local consumers. It was dried in an oven at a given temperature or under sunlight and sieved to the get the particle size of 500 µm or smaller. The influence of some major parameters which govern the efficiency of the process such as solution pH, adsorbent dose, initial dye concentration, and contact time on the removal process were investigated. For satisfactory adsorption of dye on bagasse the dye solution either taken in test tube or beaker and bagasse fly ash were shaken continuously at room temperature (27±2ºC). The equilibrium adsorption data were analyzed by the Freundlich, Nernst and Langmuir adsorption isotherm models. It was found that the highest removal was obtained at 5.0 pH, for 48 hours of treatment time and with 40 g/l of bagasse concentration. The results of this investigation clearly suggest that bagasse, a low-cost agricultural waste abundant in Ethiopia, can be used in the removal of reactive dye present in the wastewater.

INTRODUCTION

Dyeing effluents contain potentially problematic compounds because of their toxic and carcinogenic effects on aquatic life and humans. Reactive dyes are most of used in textile industries because of their favorable characteristics like bright color, water-fastness, low energy consumption and simple application techniques. Physical and chemical methods, such as chemical coagulation/flocculation, settling, oxidation, ion exchange, irradiation, precipitation and adsorption are used for de-colorization of dyes. These methods are commonly used in preliminary stages, however, with some limitations and lengthy treatment time. In the secondary treatment stage, biological wastewater treatment is often the most economical and eco-friendly alternative, relative to other physical and chemical processes. Microbial de-colorization methods, such as bio removal by growing culture in medium and bio sorption by (living or dead) microbial biomass, are commonly applied to the treatment of textile industry effluents because various microorganisms, such as bacteria, yeasts, algae and fungi, are able to remove different classes of dyes. Dye wastewater from textile industries is a serious pollution problem for environments, because it is high in both color and organic content.

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A dye is a colored substance that can be applied in solution or dispersion to a substrate in textile manufacturing, thus giving a color appearance to textile materials. Discharging of dye effluents into water resources in a small amount also can affect the aquatic life and food web in the system. Dyes can also cause allergic dermatitis and skin irritation. One of the main problem regarding textile waste-water is the colored effluent. The colored effluent contains visible pollutants. The primary concern about effluent color is not only its toxicity but also its undesirable aesthetic impact on receiving waters.

MATERIALS AND METHODS

Bagasse Collection and Adsorbent Development: The low-cost adsorbent used in this study is non-modified sugarcane bagasse collected from Sugar industries or from edible sugar cane. The sugarcane bagasse was washed and boiled several times to remove dirt, color and adherence of chemicals. The remaining solid material was dried near to 100°C for some hours in a convection oven dryer. The dried sugarcane bagasse was crushed into fine particles and kept in desiccators for further experiments.

Methods

A UV spectrophotometry was used for dye analysis (lambda 25).

Table 1. Different Parameters combination used to remove colors.

Sample number	pH	Time (Hr.)	Adsorbent dosage (g/L)	Initial dye concentration (mg/L)
1	5	12	20	50
2	7	24	40	100
3	9	48	60	150

Table 2. Initial dye and final dye concentration

Before Treatment					After Treatment		
Test No.	pH	Time (Hr.)	Adsorbent (g/L)	C_O	$C_f = C_e$	Dye removal % $= \frac{Co-Cf}{Co} * 100\%$	$qe = \frac{(Ci-Ce)V}{W}$
1	5	12	20	50	11.91	76.18	0.76
2	5	24	60	100	28.72	71.28	1.19
3	5	48	40	150	2.10	98.6	3.70
4	7	12	60	150	29.65	80.23	2.00
5	7	24	40	50	25.33	49.34	0.62
6	7	48	20	100	19.65	80.35	4.08
7	9	12	40	100	47.54	52.46	1.31
8	9	24	20	150	18.34	87.77	6.58
9	9	48	60	50	34.61	30.78	0.26

qe= amount of dye adsorbed on Bagasse (mg/g); C_i = Initial dye concentration (mg/L);
C_f =Final dye concentration (mg/L); *V* = volume of solution (L), *W*=dry weight of sorbent (g)

Figure 1. Experimental Setup of Samples at different parameters as mentioned in Table 2 (Before Treatment)

Figure 2. Experimental Setup of Samples at different parameters as mentioned in Table 2 (After Treatment)

The pH measurements were obtained using a digital pH meter and litmus papers. Rotary shaker was used for all adsorption experiments. Sieve used to separate bagasse powder according to size, pH meter to regulate pH value. To determine the number of experiments, the parameters like effect of time, pH, adsorbent dosage and initial dye concentration should be needed so the pH is varied from 5 up to 9 which lies in all medium and similarly, the time, adsorbent dosage and initial dye concentration also considered in different to assess the effect of each of parameters (Table 1).But the effects are previously checked by varying the parameters before selecting the intervals. Table 2 shows the number of experiments which generated by using statistical analysis software which is based on table 1 parameter ranges.

Adsorbate -Reactive Dyes: The name of reactive dye is Bezaktiv S-R blue which is manufactured by Bezema Company from Switzerland. And the concentration is varying from 50mg/l, 100mg/l and 150mg/l.

Adsorption Parameters: To assess the applicability of the adsorption process it is necessary to determine the kinetic parameters, using the batch technique. A series of volumetric beakers containing 100 mL capacity, containing 50 mL dye solutions of known concentrations at the appropriate or given pH and were agitated by magnetic shaker at room temperature. After a definite time, interval, the solutions were filtered and the filtrates thus obtained were then analyzed by spectrophotometric.

RESULTS AND DISCUSSION

Surface Morphology: Bagasse, the fibrous waste/ residue of the cane after crushing and extraction of the juice, consists of water, fibers and other related small quantities of water soluble solids. Its composition varies according to the variety of cane, its maturity, the method of harvesting, and finally the efficiency of the milling plant. Structurally, the cane stalk consists of various types of fiber tissue. The two most important types of fibrous residue, which occur in bagasse, are:

- The tough, hard-walled, cylindrical cells of the vascular tissues, or true fibers.
- The soft, thin-walled, irregularly shaped cells of the inner tissue, or pith.

Analysis of Adsorption Parameters: To assess the applicability of the adsorption process it is necessary to determine the kinetic parameters, using the batch technique. The following Factors are considered (adsorption parameters).Figure 1 and 2 shows experimental setup of each samples at different parameters as mentioned in table 2 before and after treatments respectively. The amount of dye removal is checked by using UV-visible spectrophotometer and the turbidity also studied after the treatment by using turbidity meter.

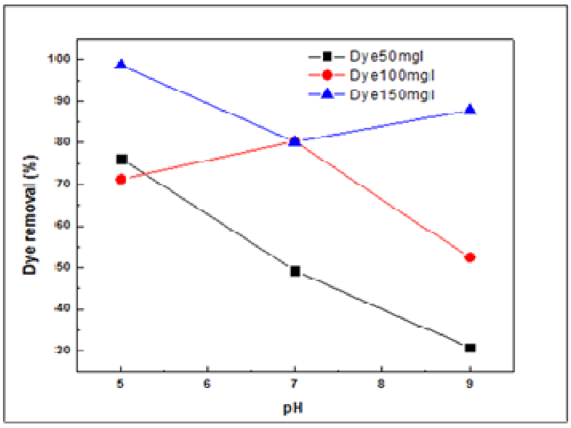

Figure 3. Effect of pH

Effect of pH

In Figure 3, when the pH increases, dye removal decrease because liberation is easy and under acidic condition bond formation between OH group is very high.

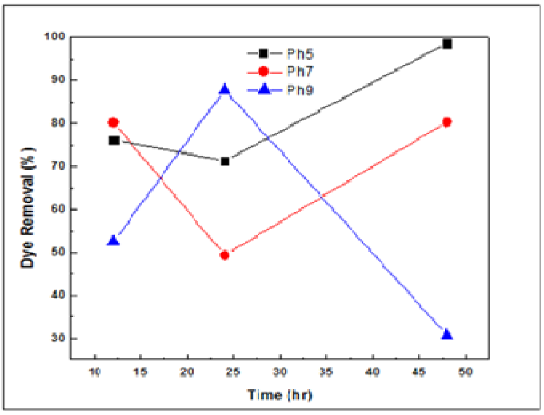

Figure 4. Effect of contact time

Effect of Contact Time

During contact time increment, bagasse gets a tendency to take or adsorb the coloring matter on its surface (Figure 4).

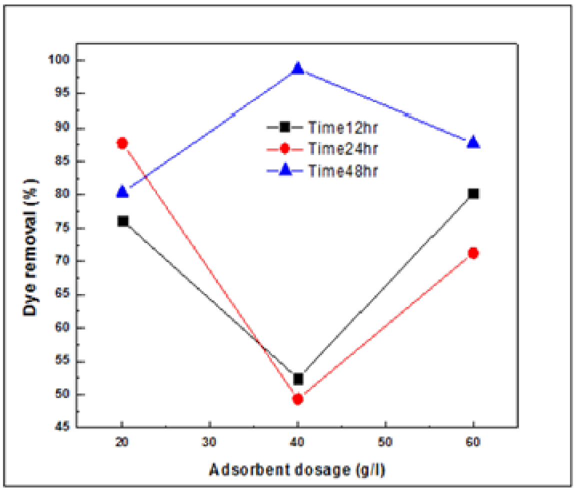

Figure 5. Effect of adsorbent dosage

Effect of Adsorbent Dosage

Basically, when the adsorbent dosage increases the amount of dye removal increased because of the presence of better adsorption area. Figure 5 indicates that the maximum dye was removed at 40g/L of adsorbent dosage.

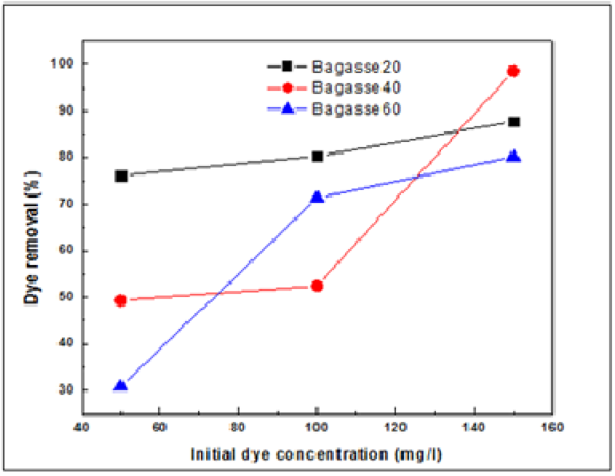

Figure 6. Effect of initial dye concentration

Effect of Initial Dye Concentration

The initial dye concentration is varied and the dye removal is studied under this variation. In figure 6 describes about the relation between dye removal and initial dye concentration, but according to different experiments. Maximum dye removal is achieved at a concentration of 150g/L.

Conclusion

Adsorption is one of the most preferred techniques for the removal of dyes and other pollutants from wastewater because of the simplicity of the method and the economic feasibility and also better microorganism development. Bagasse is an effective bio sorbent for the removal of both reactive blue-SR dyes from wastewater. It was found that the highest dye removal (98.6%) was obtained at 5.0 pH, for 48 hours of treatment time and with 40 g/l of bagasse concentration. Moreover, the decrease of particle size of adsorbent was accompanied with a removal of dyes. For venylesulphone Bezaktive red V-RB was taken and 94.2% dye removed. The present study suggests, the bagasse can be used as a sustainable adsorbent to treat or remove different reactive dyes from textile effluents effectively. The removal efficiency of bagasse was found to be affected by pH of dye solution, contact time, concentration of dye in the solution, and the amount of adsorbent.

Disclosure: Amare Worku is Currently working as Lecturer in Textile Chemistry at Dire Dawa Institute of Technology (DDIT), Dire Dawa University, Dire Dawa, Ethiopia. KrushangThakore is currently working as Professor in Textile Chemistry at Bahirdar University, Bahirdar, Ethiopia.

Conflicts of Interest: The authors declare that they have no conflicts of interest.

Acknowledgements: The authors would like to thank the financial supports from EiTEX, Bahir dar university, Ethiopia.

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