INTEGRATED ADSORPTION AND BIOLOGICAL DEGRADATION OF ACID VIOLET USING JATROPHA AND MIXED CULTURE

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Abstract : This work studies the performance of combined adsorption and biological processes for degradation of acid violet (AV) in wastewaters. The results were compared with biodegradation experiments conducted without adsorption. Jatropha was used as adsorbents whereas, mixed culture was used for biological experiments. Effect of glucose concentrations and initial concentrations of dye was studied in detail. It was observed that combined degradation was very effective in removing AV from wastewaters. Adsorption with jatropha significantly increased the mineralization capacity of pollutants.

IndexTerms **– Mixed culture, Acid violet, Biodegradation, Decolorization**

I. INTRODUCTION

Industrial wastewaters tend to carry a huge load of organic and inorganic pollutants of which organic pollutants not only appear at high concentrations but also exhibit a wide diversity with respect to their molecular structures (Wang et al., 2008; Venkata Mohan et al., 2013; Dutta et al., 2014; Balapure et al., 2015). There are several techniques for the treatment of effluents, such as incineration, biological treatment, absorption onto solid matrices, etc. However, these techniques have their drawbacks, such as the formation of dioxins and furans, caused by incomplete combustion during incineration; long periods for biological treatment to have an effect, as also the adsorptive process, that is based on the phase transfer of contaminants without actually destroying them. In physical treatment methods, photocatalytic processes using TiO_2 are considered one of the most attractive methods for the treatment of wastewater because they offer a highly reactive, non-selective oxidant, that is hydroxyl radical (OH) destroying almost every pollutant present in the wastewater (Goel et al., 2010; Mohapatra et al., 2013; Nasar, 2010; Subamaniam et al., 2016). The problem is further aggravated in the textile industry effluents, due to the complexity of their make-up. Thus it can be seen that processes are being used that are not entirely appropriate for the treatment of textile effluents, thereby creating a major challenge for the industry and laundries that need to adapt to current regulations for the control of the color of effluents with a high organic load.

Dyes are used in different industries like textile, cellulose, paper, handloom etc. After use, the dye wastes are discharged over soil or water bodies causing pollution. Due to toxicity of these dye wastes, it is necessary to treat them (Forgacs et al, 2004; Przystaś et al, 2012; Dos Santos et al, 2007).

The use of filtration membranes and/or separation (Walsh, 2001), in addition to incineration processes involving adsorption onto solid matrices, has also being adopted by the textile industry and is receiving considerable attention. However, all these processes only involve phase transfer, generating large amounts of sludge deposited at the end of the tanks and low efficiency in color removal and reduction of the organic load. According to this scenario, many studies have been carried out with the aim of developing new technologies capable of minimizing the volume and toxicity of industrial effluents. Unfortunately, the applicability of these types of system is subject to the development of modified procedures and the establishment of effluent recycling systems, activities that imply evolutionary technologies and which are not yet universally available. Thus the study of new alternatives for the treatment of many industrial effluents currently produced is still one of the main weapons to combat the phenomenon of anthropogenic contamination (Han et al., 2016; Dharajiya et al., 2016).

The aim of the present work is to explore the potential of activated jatropha being utilized as adsorbent in the combined biological and adsorptive removal of acid violet (AV) from its aqueous solution. Mixed culture obtained from the sewage treatment plant was used for biological treatment.

II. METHODOLOGY

The dye used (AV) was obtained from M/s Merck and its stock solution was prepared in double distilled water. Solutions of desired concentrations of the adsorbate were prepared from stock solution, and double distilled water was used for necessary dilutions. All reagents used in the investigation were of analytical grade. Fresh stock solution, as required, was prepared every day and was stored in a brown color glass reservoir of 5L capacity to prevent photo-oxidation. The C_0 was ascertained before the start of each experimental run by using UV Spectrophotometer.

2.1 Culture Collection:

Mixed culture was obtained from a nearby sewage treatment plant. The cultures were maintained at 4^0C in Nutrient broth. The cultures were transformed into continuous subcultures for every 10 days. The medium composition used throughout the study for biological treatment is: yeast extract (0.34 g/l), NH_4NH_3 (0.84 g/l), KH_2PO_4 (0.134 g/l), K_2HPO_4 (0.234 g/l), $MgCl_2.6H_2O$ and varying concentration of glucose.

2.2Preparation of activated Jatropha:

Jatropha Deoiled cakes was collected, dried for overnight, at 105 ^{0}C in an electric oven. The dried Jatropha cake was activated with 1:2 H_3PO_4. The activation method involved use of 100 g of jatropha with 120 ml H_3PO_4 mixed and kept overnight in room temperature. It was then activated at 500 ^{0}C for 2 hours in nitrogen atmosphere. The samples so generated were washed with distilled water (until getting pH 7), dried and sieved (at 125 microns) for use in adsorption studies.

2.3 Measurement of Chemical Oxygen Demand:

Chemical oxygen demand was measured using HACH Colorimeter (DR 890). The COD solution (HR grade – 0-1500 ppm) was prepared by mixing 0.25 ml of COD solution A and 2.8 ml of COD solution B. To this solution, 2 ml of centrifuged sample (include dilution) was added. The digestion was done at 150^{0}C in HACH COD digester for two hours using HACH COD vials. Final COD value after air cooling is taken in HACH-DR/890 colorimeter (Program No 17).

III. GENERAL PROCEDURE

3.1 Adsorption :

For each study, a 100 ml synthetic dye solution of 400 ppm concentration was prepared in 250ml Erlenmeyer flask and a known amount of adsorbent was added to each bottle, at pH 4. The solution was equilibrated for 4h at room temperature, followed by filtration of the adsorbent and subsequent analysis of filtrate for dye concentrations. The percentage removal of dyes was calculated using the following relationships:

$$\% \text{ Removal} = \frac{100(C_0 - C_e)}{C_0},$$

Where Ce the equilibrium adsorbate concentration (ppm) and C_0 is initial concentration (ppm).

3.2Integrated experiments:

The adsorbed wastewater were subjected to combined treatment using biological degradation. Appropriate quantity of inoculums and media were added to adsorbed wastewater to make up the reactor volume to 30 ml. Biological treatment for dye removal was conducted using 100 ml conical flask. The reactor was maintained at desired temperature in orbital shaker. pH 7 was maintained throughout the experiments by adding NaOH or H_2SO_4. Both the COD and dye concentrations were measured every 12 hours. The experiments were conducted for six different initial concentration of dye (100, 200,300, 400, 500 and 600 ppm). Three different glucose concentrations (1 g/l, 2 g/l and 3 g/l) and four different temperatures (25, 30, 35 and 40^{0}C) were used for the biological experiments. The experiments were also conducted for cultures without glucose. The experiments were run for 7 days. All measurements were done in duplicate. The inoculums concentration was fixed at 15%.

IV. RESULTS AND DISCUSSION

Present experiments were conducted to find the optimum adsorbent concentration for dye removal. Dye with 400 ppm inlet concentration was subjected to adsorption using activated Jatropha. The results are presented in Fig. 1. It can be seen that high adsorbent dosage enhances dye removal. During four hours of adsorption, 39% removal was observed for 1 g/l dosage which increased to 58% for 5 g/l. However, removal did not show further enhancement when the adsorbent dosage was increased beyond 5 g/l. Though increased dosage of adsorbent provide more surface area for adsorption to take place, above a certain value of adsorbent, adsorption is independent of adsorbent dosage. Thus, 5 g/l of activated jatropha was used for all the integrated treatment experiments.

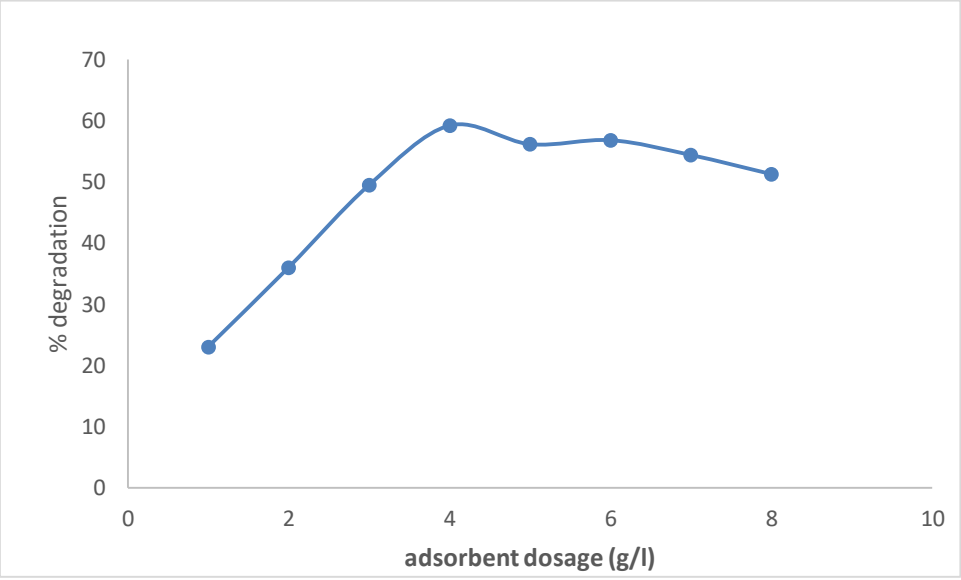

Figure 1 Effect of adsorbent dosage on adsorptive removal of AV from wastewater

4.1 Integrated treatment of AV with activated Jatropha:

With an objective to achieve further removal, adsorbed dye wastewater was subjected to biological degradation. Both the dye removal and COD removal was noted for the experiments. We studied the effect of glucose concentration and initial concentration for this work.

4.2Effect of glucose:

Figs. 2 and 3 show the dye removal for both integrated treatment and biodegradation alone at different glucose concentrations (0 g/l, 1 g/l and 2 g/l) for 400 ppm of dye. The results were observed for one week. For biodegradation alone, effect of glucose was more prominent than that of combined treatment. Increase in glucose concentration steadily increased the degradation rate of dye. The dye degradation increased from 47% to 89% as glucose concentration increased from 1 g/l to 3 g/l (Fig. 2). In case of pretreatment with adsorption, complete dye removal was observed for all the cultures, however the cultures with 2 g/l and 3 g/l glucose degraded the dye within 96 hours (four days), whereas cultures without glucose yielded the complete removal only by the end of the week for all concentrations. It was less affected by increase in glucose concentration from 2 g/l to 3 g/l. The kinetic data shows that both glucose concentration (2 g/l and 3 g/l) yielded the similar trends in degrading dye (Fig 3).

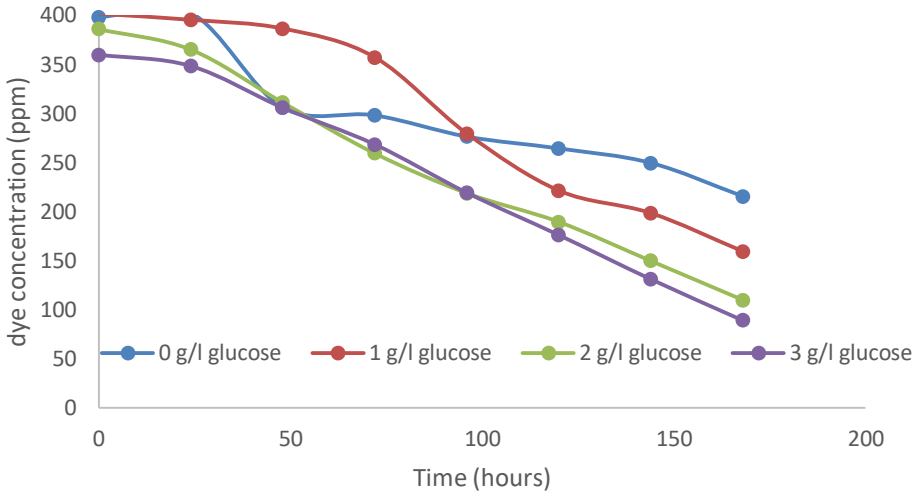

Figure 2 Biodegradation of AV at different glucose concentration without adsorption

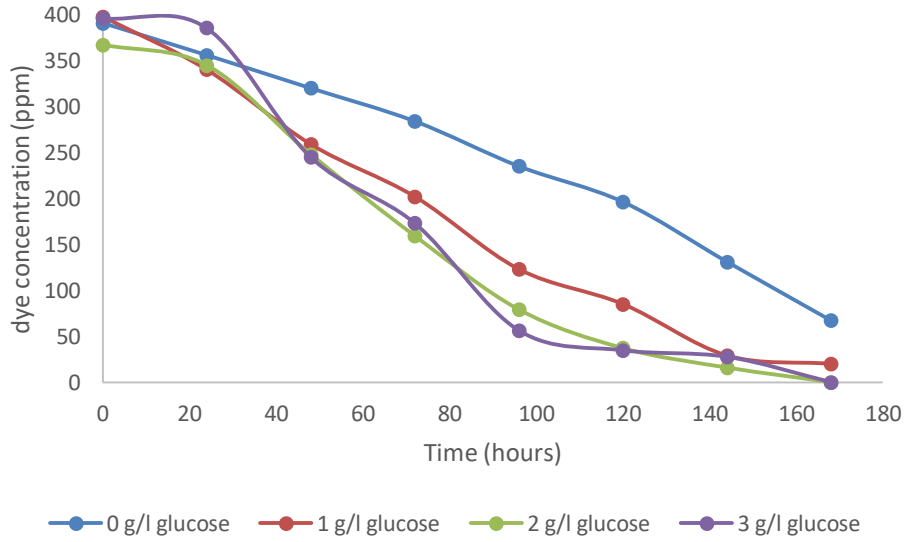

Figure 3 AV reduction for combined treatment at different glucose concentration

The results were further confirmed by COD removal data. COD removal was strongly influenced by the presence of glucose for biodegradation alone as shown in Fig. 4. On the contrary, combined treatment showed much more rigidity with respect to the presence of glucose as observed for dye degradation. Adsorption with jatropha significantly increased the mineralization capacity of pollutants. This is an important finding as it has the potential to replace expensive biogenic substrate with low cost jatropha, thus making the process much more economical.

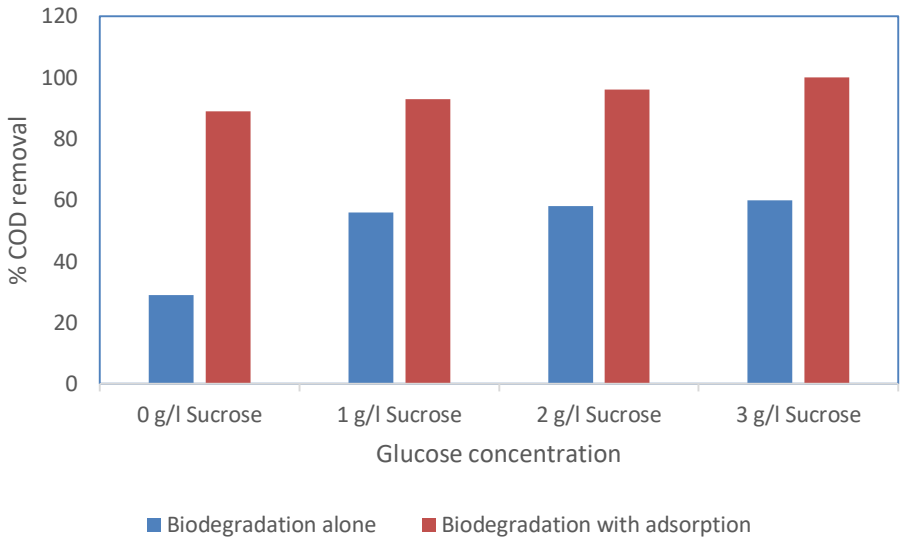

Figure 4. Demineralization data for combined treatment of AV after 4 hours of adsorption and without adsorption for all glucose concentrations

4.3. Effect of initial concentration of dye:

Biological degradations were carried out at different initial concentrations with and without adsorbed solution. Biological degradation without adsorption is presented in Fig. 5. The figure shows that for the lowest concentration (100 ppm), complete degradation took six days whereas degradation for highest concentration (600 ppm) was incomplete by the end of the week. Only 73% removal was observed. On the other hand, the process combination was much more efficient and effective in biological degradation of dyes (Fig. 6). It can be seen that for an initial concentration of 100 ppm dye, complete degradation was achieved in four days, 33% less compared to biodegradation alone. And culture with 600 ppm initial concentration got completely degraded in seven days. It can be thus noted that integrated treatment is very effective as the concentration of pollutant increases. For e.g., culture with 300 ppm initial concentration resulted in 92% removal by five days in integrated treatment, whereas the degradation rate was only 57% with biodegradation alone. Thus, integrated treatment is 43% more efficient compared to biodegradation alone.

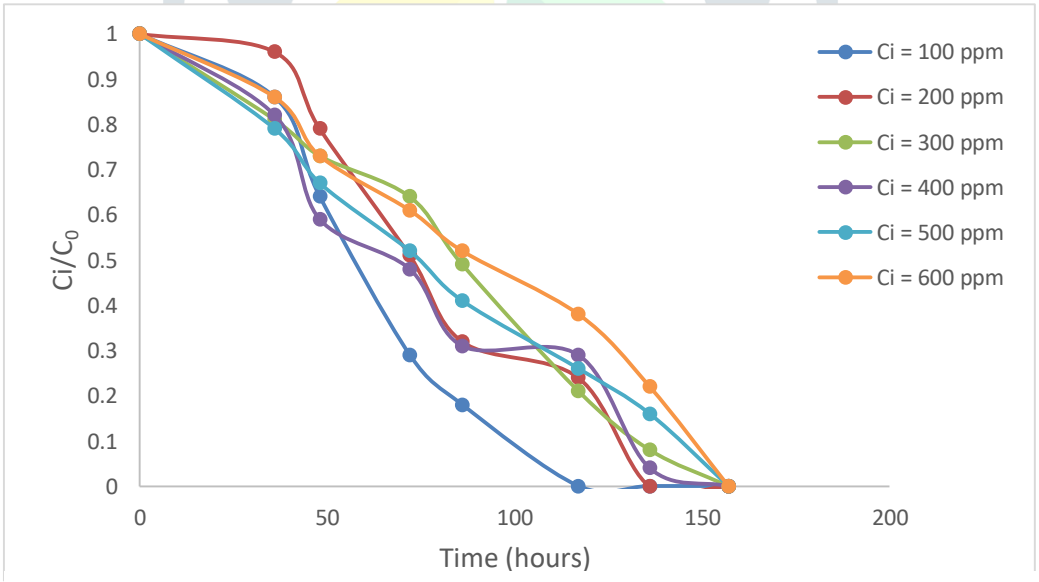

Figure 5 Biodegradation of AV at different initial concentration without adsorption

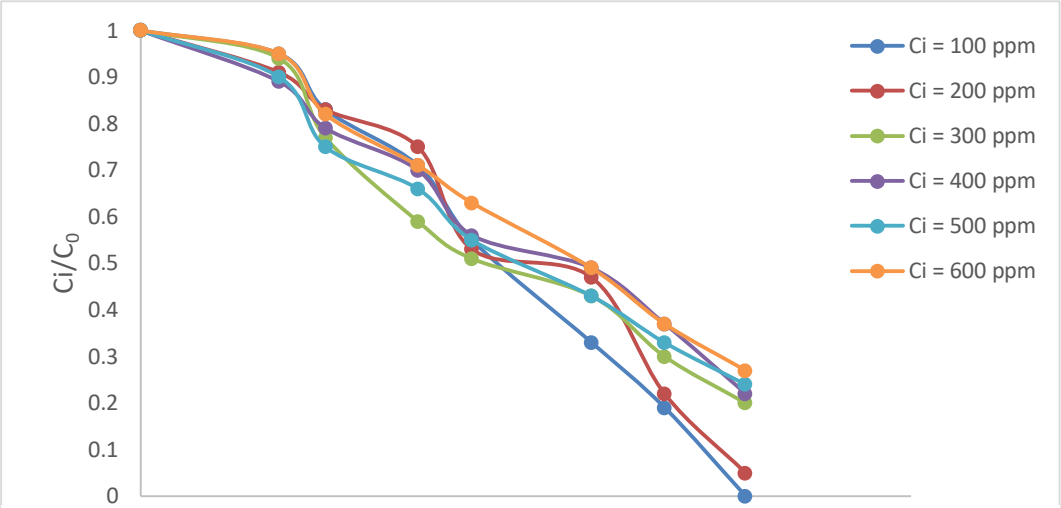

Figure 6 AV reduction for combined treatment at different initial concentration

COD removal rate data shows the same trend. COD removal rate is detailed in Table 1 for both biodegradation alone and integrated treatment. Integrated treatment yielded in complete COD removal for cultures with 100 ppm concentration. However, biodegradation alone could result in only 57% removal. Similarly COD removal for higher concentrations (600 ppm) is efficiently degraded by integrated treatment than biodegradation alone.

Table 1 Effect of Dye concentration on COD removal of dye wastewater

	Biodegradation alone				**Biodegradation with adsorption**			
	Glucose concentration				Glucose concentration			
Dye concentration (ppm)	0 g/l	1 g/l	2 g/l	3 g/l	0 g/l	1 g/l	2 g/l	3 g/l
100	56	58	61	74	94	98	100	100
200	53	51	57	64	88	96	100	100
300	51	48	54	62	81	93	99	100
400	48	38	51	56	79	78	98	99
500	34	34	48	53	75	87	91	92
600	21	31	42	41	68	85	88	90

V. CONCLUSION

The present study effectively degrades the dye acid violet (AV) using combined adsorption and biological process. Effect of glucose concentration and initial concentration of dyes were studied in detail. It was found that combined degradation did not show much importance to glucose concentration as it increased from 2 g/l to 3 g/l whereas biodegradation was affected by increase in glucose concentration. The dye degradation increased from 56% to 81% as glucose concentration increased from 1 g/l to 3 g/l in case of biodegradation. Furthermore, integrated treatment is very effective as the concentration of pollutant increases. On the other hand, biodegradation alone yielded poor performance and only 49% of degradation was observed.

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