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Research Article

Removal of Auromine-O Dye from Dye Wastewater by Adsorption using Seeds of Annona Reticulata

H.Revathi[†*], T.Murugan [‡] and R.Sharmila Devi[†]

[†] Department of Chemistry, Karpagam University, Coimbatore, Tamilnadu, India
[‡] Department of Chemistry, Suguna College of Engineering, Coimbatore, Tamilnadu, India

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Abstract

The biomass adsorbent prepared from seeds of Annona Reticulata (custard apple) was used to remove Auromine-O dye from wastewater by adsorption. Effect of various experimental parameters such as initial concentration of dye, effect of pH, biomass dose and equilibration time were studied and properly examined. Batch adsorption studies were carried out at room temperature (30±1^0 c). At pH 7 the Auromine- O dye could be removed effectively by custard apple biomass. Mathematical equations have been designed for the wide range of applications. The results showed that the dye, Auromine-O strongly interacts with a biomass based adsorbent, the custard apple seeds powder.

Keywords: *Custard apple seeds powder (CASP), Biomass adsorbent, Auromine-O dye, Adsorption.*

1. Introduction

Water is one of the important ecosystem for existence of the biotic species including human. If we not save the water properly it would leads to loss of biodiversity. Pollution caused by effluents from industries is a major environmental problem faced by many countries. At present most of the natural water sources are polluted by adding domestic, agricultural and industrial waste. This has resulted in the generation of large amounts of waste water (Seshadri, *et al*, 1994) containing a number of pollutants. Among these, dyes and pigments are one of the important class of the pollutants. Dyes and pigments are widely used in textile, paper, leather, plastics, cosmetics, pharmaceutical and food industries. The extensive use of dyes often poses pollution problems in the form of colored waste water discharged into stream, pond, river and various natural sources of water. Dyes usually have a synthetic origin and complex aromatic structure. They are more stable and difficult to biodegrade (Nigam, *et al*, 2002). Today more than 1,00,000 commercial dyes are available with a rough estimated production of $7x10^5$ – $1x10^6$ tons per year(Chen, *et al*, 2003). Many dyes and pigments have toxic as well as carcinogenic, mutagenic and teratogenic effects (Panswed and Wongchaisuwan, 1986), on aquatic life and also on humans. Dyes imparts color to water which is highly objectionable on aesthetic grounds. Color acquired by water body through the discharge of effluents reduce the transmission of light and affect the photosynthetic activity which cause the destruction of aquatic communities present in the ecosystem(Malik and Saha, 2003). Further the dyes have a tendency to sequester metal ions and may cause microtoxicity to fish and other organisms(Koch, *et al*, 2002). Hence it is essential to treat colored effluents before it is discharged into various water sources.

The methods generally used for treating waste waters are coagulation and flocculation(Ciardelli, et al, 2002), oxidation, chlorination(Venkata and Sastray, 1987), ozonation (Robinson et al,2002), sonolysis (Namasivayam, *et al,* 1996), ion exchange(Nassar, 1999), and activated carbon adsorption. Activated carbon is probably the most widely used adsorbent material in industrial and environmental applications regarding to its highly micro-porous morphology, high internal surface area, and porosity (Chang, *et al*, 2000). Activated carbon from any material is rich in carbon content or any agricultural waste make it commercially available (Isah and Yusuf, 2012). But regeneration process of activated carbon is very costly. Hence we have undertaken an attempt to prepare low cost, easily available biomass adsorbents for the removal of coloring matter from wastewater. A number of studies have been carried out successfully for removal of dyes by various types of biomass materials (Low *et al.*, 1995).

The Annona Reticulata tree(custard apple)is an evergreen plant which is largely available and cultivated in India. The tree itself is known as an air purifier and different parts of the tree such as leaves, fruits and seeds have been reported to possess a

*Corresponding author: **H.Revathi**

variety of medicinal and germicidal properties. In the present work finely ground custard apple seed powder(CASP) was used as an adsorbent for dyes using aqueous Auromine-O dye as a model system.

The adsorbate selected in this study was Auromine-O(λ_{max}=470nm). The Auromine-O dyes are largely used in textile, rubber, paper and leather industries. The effect of various operating parameters on adsorption such as particle size, sorbent dosage, contact time, initial dye concentration and pH were monitored and optimal experimental conditions were maintained.

2. Materials and methods

The custard apple seeds powder (biomass) used in this study were collected from local fields. The collected biomass material was extensively washed with tap water to remove soil and dust, sprayed with distilled water then dried in an oven at 80^0 C to a constant weight. These dried custard apple seeds powder were crushed in a mechanical crusher to a constant powder size which were fractionated to 450µ and preserved as an adsorbent in air tight glass bottles.

Preparation of dye solution and estimation

The direct dye Auromine-O analytical grade was used without further purification. The dye stock solution was prepared by dissolving accurately weighed dye in distilled water to concentration of 1000mg/l. The experimental solution were obtained by diluting the dye stock solutions in accurate proportions to different initial concentrations.

The appropriate dye solution was transferred into a 10mm quartz cuvette cell and absorbance was measured in the range of 340-350 mm against distilled water blank as a reference. The observations are presented in the table 1.

The plot of wavelength Vs absorbance is presented in the Fig1. From the plot, it is observed that the λ_{max} is at 470nm where the maximum absorbance is 0.769. Hence, wavelength of 470nm has been used in all further studies.

Table 1 Effect of wavelength on absorbance

S. No.	Wave length (nm)	Absorbance
1	340	0.348
2	360	0.382
3	380	0.426
4	400	0.467
5	420	0.504
6	440	0.546
7	450	0.563
8	460	0.580
9	470	0.769
10	480	0.563
11	490	0.542
12	510	0.418
13	530	0.376
14	550	0.332

Table 2 Effect of wavelength on absorbance

S. No.	Wave length (nm)	Absorbance
1	440	0.546
2	445	0.555
3	450	0.563
4	455	0.573
5	460	0.580
6	465	0.593
7	470	0.769
8	475	0.574
9	480	0.563
10	485	0.556
11	490	0.542
12	495	0.521
13	500	0.447
14	505	0.429
15	510	0.419

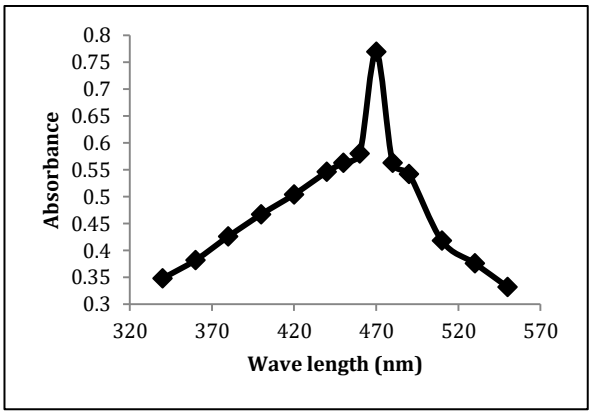

Fig.1 Effect of wavelength on absorbance

Batch Experiments

Batch experiments were conducted in stoppered reagent glass bottles of 250 ml capacity, which were provided with glass caps. 100 ml of different concentration of dye solutions under investigation was taken in each stoppered reagent bottles . After addition of biomass, the stoppered reagent glass bottles were equilibrated for the predetermined period of time in a rotary mechanical shaker. The initial pH values of the solutions were previously adjusted with 0.1 N sulphuric acid or sodium hydroxide using pH meter. Then the solutions were filtered and adsorbent of the filtrates were measured using UV visible spectrophotometer.

Batch experiments were conducted for maximum biosorption of dye ions through the following parameters.

1) Effect of initial concentration
2) Effect of contact time
3) Effect of pH 4.Biomass dose.

3. Results and Discussions

3.1 Effect of Biomass dose

To find out the minimum amount of biomass required for maximum percentage of dye adsorption, a series of 100 mg/l dye solutions were taken in stoppered reagent glass bottles and a varying quantities 0.1 to 1.4 g of biomass were added and equilibrated using rotary mechanical shaker for five hours. After equilibration, the absorbance of the supernatant liquid was measured. The percentage of dye removal was calculated. The results are presented in Table.3 and the corresponding plot of biomass dose against percentage of dye removal is shown in Fig.2. From the figure it is observed that 85.7% of adsorption, biomass dose of 1.4 gms are required . Hence in all the further studies the optimum weight of 1 gm of biomass dose was maintained.

Table 3 Effect of Biomass dose (Size 400 micron)

S. No.	Biomass dose (g)	Percentage of dye removal in Custard apple seeds
1	0.1	27.78
2	0.3	57.59
3	0.5	63.03
4	0.7	77.91
5	0.9	80.81
6	1.0	81.08
7	1.1	81.86
8	1.2	83.34
9	1.3	85.32
10	1.4	85.70

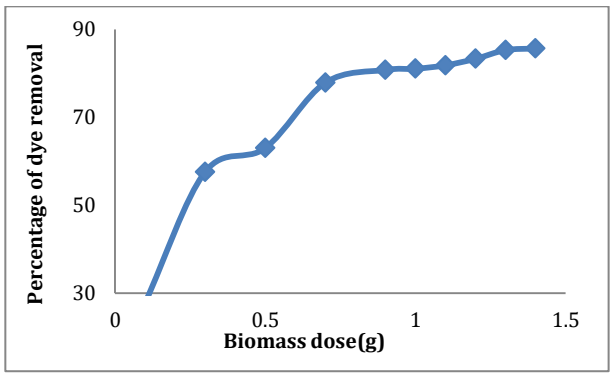

Fig.2 Effect of Biomass dose (Size 400 micron)

3.2 Effect of Equilibration period

In a series of 10 reagent bottles, 100 ml of 100 mg/l of dye solution was taken and 10 ml of pH of 7 is added. To this 1.0 gm of biomass (custard apple seed) powder is added separately. These bottles were agitated in a mechanical shaker at time of 30 minutes interval. Bottles were isolated from the shaker and kept aside for few minutes. Then the contents are filtered and the filtrate is subjected for absorbance measurements.

Thus the systems were allowed for different time intervals in the range of 30 to 240 minutes. The results are presented in Table. 4 and the plot of contact time against the percentage of dye removal is shown in Fig. 3. From the results, it is concluded that an equilibration period of 240 minutes was necessary for the maximum percentage of dye removal by custard apple seeds.

Table 4 Effect of Equilbration period

S. No.	Contact time(min)	Percentage of dye removal in Custard apple seeds
1	10	63.06
2	20	64.45
3	30	65.64
4	60	65.67
5	90	69.42
6	120	70.61
7	150	70.72
8	180	70.85
9	210	71.08
10	240	71.60

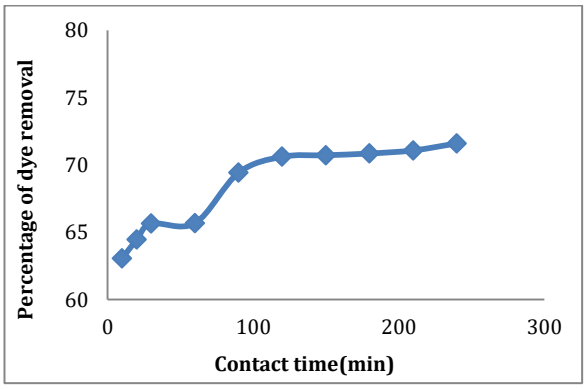

Fig.3 Effect of Equilibration period

3.3 Effect of pH

Batch adsorption studies were carried out to find the effect of pH on the color removal of dye using 100 ml of 100 ppm dye solutions with one gram biomass dose and adjusted to different pH values of 2 to 9 with 0.1 N sulphuric acid and 0.1 N sodium hydroxide. The systems were equilibrated for 5 hours. The absorbance of the filtrate were measured. The results are presented in Table. 5. The plot of pH against percentage of color removal was shown in Fig. 4. It is observed that in pH range 8-9, biomass adsorb to the extend of 84.30%. Hence in all further studies pH=8 was selected and maintained.

Table 5 Effect of pH on adsorption

S. No.	pH	Biomass dose (g)	Percentage of dye removal in custard apple seeds
1	2	1.0	61.46
2	3	1.0	65.42
3	4	1.0	70.10
4	5	1.0	76.20
5	6	1.0	78.10
6	7	1.0	82.04
7	8	1.0	83.01
8	9	1.0	84.30

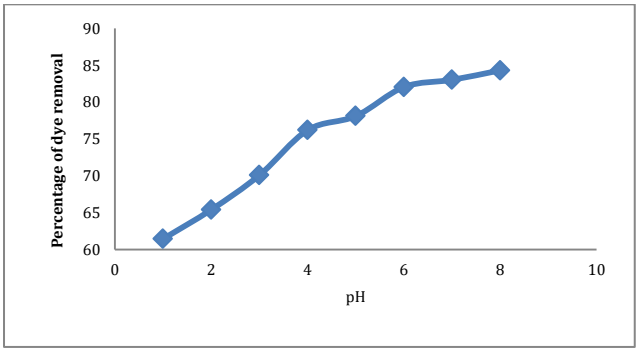

Fig.4 Effect of pH

Scanning Electron Microscopy

The Fig.5 shows the Sem micrograph of CASP samples before dye adsorption. It shows custard apple seeds powder possesses rough surface morphology with pores of different sizes. These pores are useful for dye adsorption.

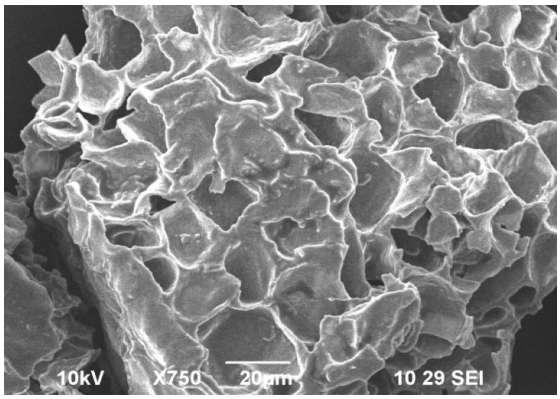

Fig.5 SEM micrograph of Custard apple seeds(Annona Reticulata) (750x) before adsorption

Conclusion

The custard apple seed biomass are prepared from locally available Annona Reticulata plant tree. After removal of chlorophyll 450µ size of biomass particles are selected for adsorption study. The adsorptions of the dye on the biomass are almost 85 to 86%. Large scale removal of the dye is happening with equilibrium periods, but equilibrium build up after 1 hour. The optimal pH for favorable adsorption of dyes was 8 to 9. The biomass after use can be disposed without any effects are burnt easily. The percentage of dyes sorbed increased then reached maximum values as the sorbent dose was increased. This study showed that custard apple seeds powder (CASP) could be effectively used to remove Auromine-O dye from aqueous solution.

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