Removal of Methylene Blue from Aqueous Solution: An Approach of Environmental Friendly Activated Carbon

M. C. Jayaprakash, M. Chaitra, Prarthana Rai, and D. Venkat Reddy

Abstract Methylene blue (MB) dye was adsorbed on an adsorbent prepared from cashew nut shell. A batch adsorption study was carried out with variable adsorbent amount, initial dye concentration and contact time. Studies showed that as the contact time increases relatively there will be an increase in the removal of methylene blue from the aqueous solution. There was also a comparative increase in the removal of dye with the increase in dosage of adsorbent. As the concentration of MB dye increased the percentage of removal of MB from the aqueous solution decreased for a given particular dosage. The results indicate that cashew nut shell activated carbon could be employed as a low-cost alternative to commercial activated carbon in the removal of dyes from wastewater. This work offers an economic incentive to the industrial practice for waste management and eco-friendly approach for removal of toxic dyes from textile waste water.

Keywords Methylene blue · Cashew nut shell · Activated carbon

1 Introduction

Over the last few decades, society has also become increasingly sensitive towards the protection of the environment. Due to this problem, mankind now-a-days is concerned about the potential adverse effects of the chemical industry on the environment, although the response in some parts of the world has been much faster and more intense than in others. The colour manufacturing industry represents a relatively small part of the overall chemical industry. Dyes and pigments are highly

M. C. Jayaprakash (✉) · M. Chaitra · P. Rai
Department of Civil Engineering, Mangalore Institute of Technology and Engineering, Badaga Mijar, Moodabidri 574225, India
e-mail: jayaprakash@mite.ac.in

D. Venkat Reddy
National Institute of Technology Karnataka (NITK), Mangalore, India

L&T Constructions, Chennai, India

K. R. Reddy et al. (eds.), *Sustainable Environment and Infrastructure*, Lecture Notes in Civil Engineering 90, https://doi.org/10.1007/978-3-030-51354-2_16

visible material. Thus even minor release into the environment may cause the appearance of colour, for example in open waters, which attracts the critical attention of public and local authorities.

There is thus the requirement on industry to minimise environmental release of colour, even in cases where a small but visible release might be considered as toxicologically rather innocuous. A major source of release of colour into the environment is associated with the incomplete exhaustion of dyes onto textile fibre from an aqueous dyeing process and the need to reduce the amount of residual dye in textile effluent has thus become a major concern in recent years. An alternative approach to addressing the problem of colour in textile dyeing effluent has involved the development of effluent treatment methods to remove colour. These methods inevitably add to the cost of the overall process and some present the complication associated with the possible toxicity of degraded products.

To comply with discharge standards, most industries and institutions practice an elaborate effluent and sewage treatment protocol which affects the overall economy of the plant. A conventional continuous flow process requires multiple structures and extensive pumping and piping systems. The need of the hour is a suitable technology for efficient and cost-effective tertiary treatment for recycling or reusing at least a reasonable quantity of the wastewater produced in the plant.

Biological treatment of organic waste using activated sludge is a proven technology used in wastewater treatment facilities. Conventional aerobic and anaerobic treatment processes have been used to reduce the organic carbon concentration of liquid, but these processes have not been successful in reducing both carbon and nitrogen at a reasonable cost. The effluent from primary treatment of wastewater will still have some odour and turbidity and is usually removed by chemical coagulants. However traces of these coagulants will be retained in effluent after coagulation and need to be removed separately. Hence removal of traces of coagulants is an additional cost.

The main advantage of proposed treatment system is the minimization of investment and operational costs as compared to the use of different conventional set ups as followed in tertiary wastewater and colour removal treatments. Using the result of this study, an abundantly available waste by-product of several local industries can be turned into a low-cost activated carbon on large scales efficiently. The carbon can be used for better and more efficient wastewater and colour removal treatment and simultaneously reduce costs. **This work offers an economic incentive to the industrial practice for waste management and eco-friendly approach for removal of toxic dyes from textile waste water in a sustainable manner**.

2 Objectives

- To develop a low-cost activated carbon from the cashew nut shell.
- Removal of methylene blue by adsorbing it onto the prepared cashew nut shell activated carbon.

- Treating the secondary waste water from the cashew nut shell activated carbon by adsorption.

3 Methodology

3.1 Preparation of Activated Carbon

- Preparation of activated carbon from the cashew nut shell.
- Methylene Blue solution was prepared by varying the concentration i.e., 5 ppm, 10 ppm, 20 ppm, 30 ppm, 40 ppm and 50 ppm by using distilled water.
- Conducting the adsorption process by adding cashew nut shell activated carbon in the methylene blue solution.
- Conducting trials by varying the concentration of methylene blue solution, agitation time, sieve size of activated carbon and adsorbent dosage.
- Treating the secondary waste water by the prepared cashew nut shell activated carbon and checking for variation in pH, turbidity, BOD, COD and alkalinity.

The Activated carbon (AC) taken for the experiment are of size 150 microns, 90 microns and 75 microns.

4 Results and Discussion

4.1 SEM Results of Cashew Nut Shell Activated Carbon

To identify the characteristic morphology of samples SEM cashew nut shell charcoal was determined. The SEM images clearly show that pores of different shapes and size are present on the surface of the samples (see Figs. 1, 2 and 3 for 75, 90 and 150

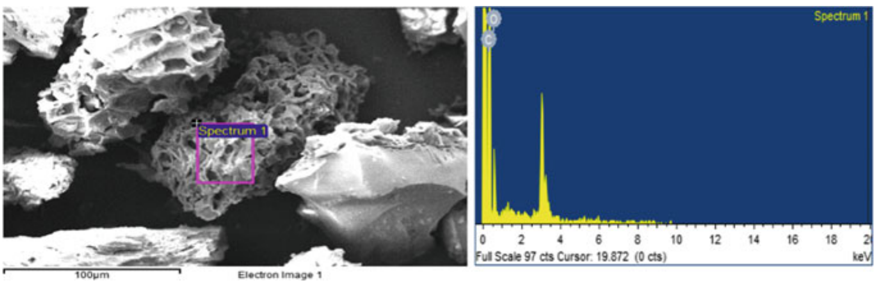

Fig. 1 SEM spectrum of 75 microns sieve sized activated carbon

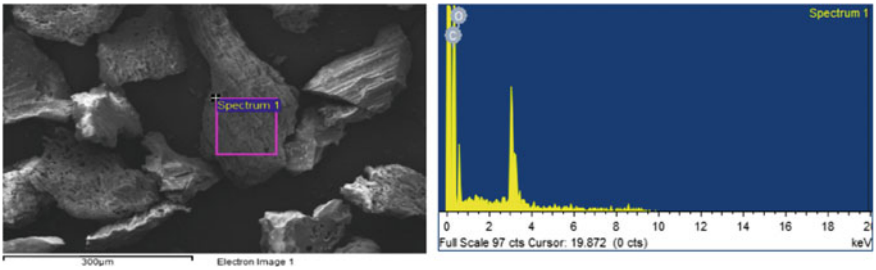

Fig. 2 SEM spectrum of 90 microns sieve sized activated carbon

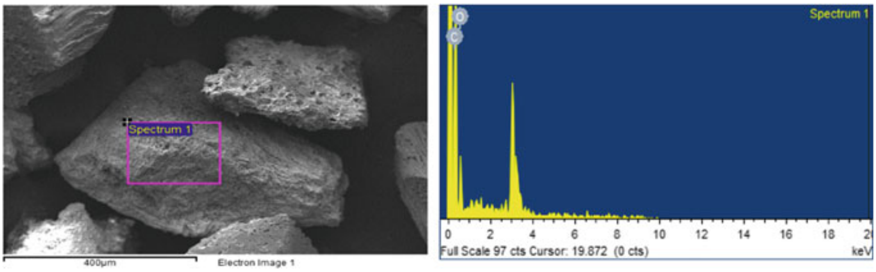

Fig. 3 SEM spectrum of 150 microns sieve sized activated carbon

Table 1 Elemental composition of cashew nut charcoal sample of 75 microns by SEM

Element	Weight %	Atomic %
$CaCO_3$ (C) K	77.63	82.21
SiO_2 (O) K	22.37	17.79

micron size). SEM spectra shows that cashew nut charcoal composed of Calcium, Oxygen and Carbon elements (Tables 1, 2 and 3).

Table 2 Elemental composition of cashew nut charcoal sample of 90 microns by SEM

Element	Weight %	Atomic %
$CaCO_3$ (C) K	77.94	82.47
SiO_2 (O) K	22.06	17.53

Table 3 Elemental Composition of cashew nut charcoal sample of 150 microns by SEM

Element	Weight %	Atomic %
$CaCO_3$ (C) K	76.80	81.51
SiO_2 (O) K	23.20	18.49

4.2 Removal of Methylene Blue from Aqueous Solution

The result shows varying concentration of MB with different particle size of carbon and same concentration of MB with different weight of carbon, the 75 micron particle size of carbon showed 96.20% (Table 4 and Fig. 4 at 5 ppm initial concentration with weight of carbon 0.5 g in 2 h agitation time) of maximum colour recovery, whereas the 75 micron particle size of carbon showed 96.75% (Table 5 and Fig. 5 at 40 ppm

Table 4 Varying concentration of MB with different particle size of carbon

Particle Size of Adsorbent (Microns)	Conc. (ppm)	Wt. of Carbon in grams	Conc. Obtained in (ppm): 1 h Agitation	Conc. Obtained in (ppm): 2 h Agitation	% of recovery (1 h Agitation)	% of recovery (2 h Agitation)
75	5	0.5	0.35	0.19	93	96.20
	10	0.5	1.17	0.85	88.3	91.50
	20	0.5	9.48	7.2	52.6	64
	30	0.5	19.7	19.7	34.33	34.33
	40	0.5	36.1	35.8	9.75	10.50
	50	0.5	47.7	47.7	4.6	4.6
90	5	0.5	0.73	0.34	85.4	93.2
	10	0.5	2.38	1.9	76.2	81
	20	0.5	10.85	9.76	45.75	51.2
	30	0.5	25	23.2	16.67	22.67
	40	0.5	36.6	36	8.5	10
	50	0.5	48	47.8	4	4.4
150	5	0.5	1.4	0.62	72	87.6
	10	0.5	4.67	3.33	53.3	66.7
	20	0.5	13.86	13.39	30.7	33.05
	30	0.5	28.2	26.8	6	10.67
	40	0.5	38.3	37.8	4.25	5.5
	50	0.5	48.2	48	3.6	4

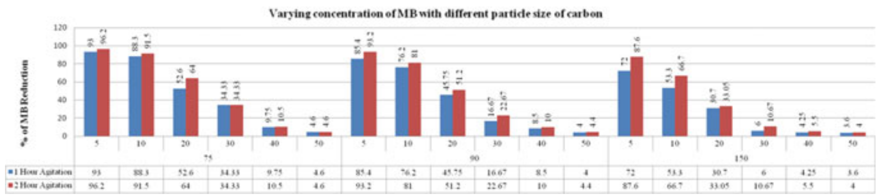

Fig. 4 Graph showing removal percentage of MB with different particle size of 75, 90 and 150 micron and keeping weight of carbon 0.5 g

Table 5 Same concentration of MB with different weight of carbon

Particle Size of Adsorbent (Microns)	Conc. (ppm)	Wt. of Carbon in grams	Conc. Obtained in (ppm): 1 h Agitation	Conc. Obtained in (ppm): 2 h Agitation	% of recovery (1 h. Agitation)	% of recovery (2 h Agitation)
75	40	0.5	36.1	35.8	9.75	10.50
		1	2.1	3.2	94.75	92
		3	1.6	1.8	96	95.50
		5	1.3	1.7	96.75	95.75
90	40	0.5	36.6	36	8.50	10
		1	16.6	15.3	58.50	61.75
		3	2.5	2.2	93.75	94.50
		5	2.1	2.1	94.75	94.75
150	40	0.5	38.3	37.8	4.25	5.50
		1	36.4	33.3	9	16.75
		3	10.7	7.2	73.25	82
		5	4.8	3.3	88	91.75

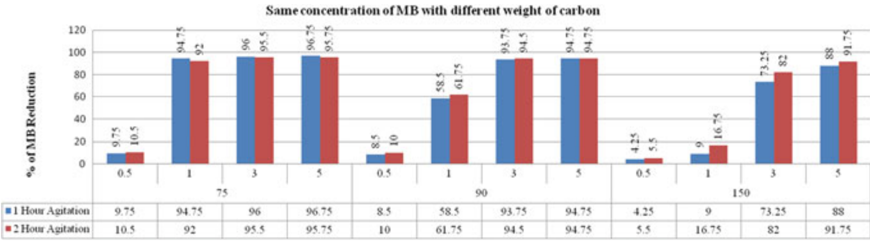

Fig. 5 Graph showing removal percentage of MB with different weight of carbon and keeping concentration 40 ppm of MB

initial concentration with weight of carbon 5 g in 1 h agitation time) compare to 90 and 150 micron size. Hence, the decreasing particle size will increase removal of methylene blue dye from the aqueous solution and decreasing particle size will have more surface area for the effective adsorption with short duration of agitation.

5 Conclusions

The activated carbon prepared by using cashew nut shell charcoal is very efficient to remove methylene blue dye from aqueous solution since the carbon content in the cashew nut activated carbon is high as shown in the SEM results. It is also observed that as the sieve size of the activated carbon decreased and as the agitation time increased the removal of methylene blue dye from the aqueous solution was more. The quality of the carbon obtained will depend on the quality of the raw material in general, and its residual oil content in particular. This obtained result can show considerable promise of cashew nut shell charcoal as a raw material for activated carbon.

References

1. Lubi MC, Thachil ET (2012) Cashew nut shell liquid (CNSL)- a versatile monomer for polymer synthesis" by (2012)
2. Senthi Kumar P, Ramalingam S, Senthamarai C, Niranjanaa M, Vijayalakshmi P, Sivanesam S (2010) Adsorption of dye from aqueous solution by cashew nut shell: studies on equilibrium isotherm, kinetics and thermodynamics of interactions
3. Senthil Kumar P, Ramalingam S, Sathishkumar K (2010) Removal of methylene blue dye from aqueous solution by activated carbon prepared from cashew nut shell as a new low-cost adsorbent
4. Mane RS, Bhusari VN (2013) Removal of colour (dyes) from textile effluent by adsorption using orange and banana peel. Int J Eng Res Appl Chem 2013. article ID 614083, 9 pages
5. Sanger SH, Mohod AG, Khandetode YP, Shrirame HY, Deshmukh SS (2011) Study of carbonization for cashew nut shell. Res J Chem Sci 1(2):43–55
6. Ramalingam S, Senthil Kumar P (2015) Novel adsorbent from agricultural waste (cashew NUT shell) for methylene blue dye removal: Optimization by response surface methodology
7. Syafalni S et al (2012) Treatment of dye wastewater using granular activated carbon and zeolite filter. Modern Appl Sci 6(2)