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Decolorization of Textile Effluents Applying Sequential Operation of Prepared Activated Carbons

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Abstract

Three activated carbons were prepared from bio-waste material and their adsorption efficiency in removal of textile effluents was tested. During sequential operation of these carbons, textile effluents were decolorized with better results like 7, 5 and 3 m^{-1} absorbance at wavelengths of 436, 525 and 620 nm respectively. 2 g of each adsorbent and at optimum contact time of 40 min removed 93% of color form collected textile effluents.

Keywords: Textile effluents; Activated carbon.

1. Introduction

Textile industries consume large volumes of water, dyes and auxiliary chemicals for processing of textiles. Due to incomplete exhaustion and washing operations, 10-20% of dyes were discharged into effluents [1]. Many of these dyes were toxic and carcinogenic thus affecting the aquatic biota and human health [2]. The world population was expected to be increased by 35% by 2050 [3].

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This population growth will increase the production of clothes, which in turn, increases fresh water use. So conserving water and reducing water pollution will become a challenging and essential task for textile industries. Dharmavaram region in Ananthapur is world famous for the handmade pure silk sarees.

It is a major hub for Silk trade with end to end silk related industries situated in the region supporting a major portion of population. Weavers in and around Dharmavaram tend to work from home with all members of family giving in their bits at different levels of the weaving process. Textile effluents are collected from fabric dyeing place in Dharmavaram. The process of fabric dyeing and the discarded effluents were shown in Figure 1. Weaving of series on looms is the livelihood for many people in Dharmavaram. These weavers are using different dyes in dye bath for the requirement of color. These commercial dyes contain mixture of dyes and does not provide any scientific information regarding structure, chemical composition etc.

Textile effluents sewage directly enters water streams without any treatment. The toxicity was not only caused by textile dyes but also by a large number of different textile chemicals.

The effluents are collected from three different places of their disposal. The efficiency of prepared carbon adsorbents in decolorizing these textile effluents was studied.

2. Material and Method of preparation:

Jack fruit-*Pichiparai-1* variety was collected from state horticulture mission, Paderu, Visakhapatnam, A.P., India. The rind and pulp waste of fruit was used as precursor for preparation of activated carbon. The waste was washed with hot distilled water dehydrated at 105^{o}C. This dried waste was then cut into small pieces. It was mixed with K_2CO_3 solution in 1:1 ratio and was carbonized in uniform nitrogen flow at 600^{o}C. The heating was provided at rate of 10^{o}C min^{-1}. The prepared activated carbons were cooled to room temperature and washed with hot distilled water to remove remaining chemical and filtered. The washing and filtration steps were repeated until the filtrate showed neutral pH and finally dried. It was named as JC_{600}. In order to introduce different functional groups, JC_{600} was divided into two parts. One part was subjected to liquid phase oxidation with 0.1N HNO_3 and the other part was soaked in 0.1N KOH for 3 hr and evaporated at 110^{o}C. Both carbons were washed with distilled water until filtrate showed neutral pH. These carbons were dehydrated in an oven overnight at 105^{o}C and named as 'JC_{HNO_3}' and 'JC_{KOH}', indicating the chemical activating agent.

3. Experimental method:

All the experiments were carried out in 250 ml conical flasks with 100 ml textile effluent at room temperature (25±2^{o}C). Textile effluents were directly taken without prior filtration. The flasks, along with test solution and 1 g of the adsorbent were shaken in horizontal shaker at 120 rpm for 60 min and filtered. For this 100 ml of textile effluent was first treated with JC_{600} and the solution was filtered, the filtrate was treated with JC_{HNO_3} adsorbent for 1 hr. It was then filtered and finally similar process was also followed with JC_{KOH} activated carbon under similar experimental conditions. Applying German standard method DIN 38 404 [4, 5, 6], measurement of color absorbance (in m^{-1}) was done at the standard wavelengths of 436, 525 and 620 nm at each stage [7].

Figure 1: *(**a**) Commercial dyes & other chemicals for dyeing fabric (**b**) Dyeing fabric in hot bath (**c**) Washing dyed fabric (**d**) Effluent ready to discard (shown with arrow) (**e**) Effluents from different dye processes (**f**)*

4. Results and discussions

4.1 Characteristics of textile effluents before treating with carbons

The effluents were highly colored with offence odor. They contain few suspended particles. Samples 1 and 2 were in red color and reaming sample 3 is in blue color and the color absorbance values were given in Table 1. High values of COD and BOD observed for all the three samples.

Table 1: Textile effluents characteristics before treating with carbons.

Samples	**pH**	**COD** (mg l^{-1})	**BOD** (mg l^{-1})	**Turbidity** (NTU)	**Conductivity** (mS cm^{-1})	**Suspended solid** (mg l^{-1})	(mg l^{-1})	**Color absorbance** (absorbance m^{-1})		
								436 nm	**525 nm**	**620 nm**
Sample 1	7	353	45	8.2	3.1	10	2.1	95	121	114
Sample 2	8	256	71	9.6	2.5	21	1.9	41	85	56
Sample 3	6	410	26	12.1	1.9	17	1.4	105	93	69

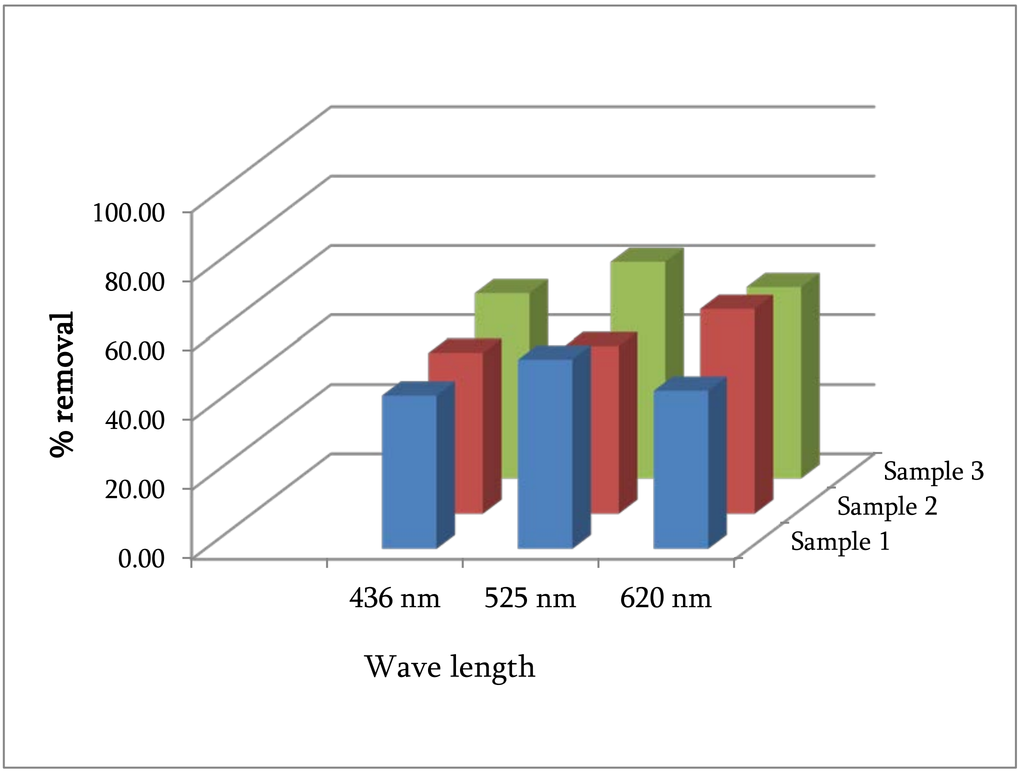


Figure 2: Testing the efficiency of prepared adsorbents in color removal from textile effluents.

4.2 Characteristics of textile effluents after treating with carbons

After treating with JC_{600}, JC_{HNO_3} and JC_{KOH} activated carbons the changes in characteristics of textile effluents were compiled in Table 2 and the corresponding graph was shown in Figure 2. After treating with activated carbons, great reduction in COD and BOD values was also observed.

Table 2: Testing the efficiency of prepared adsorbents in color removal from textile effluents.

Samples	pH	COD (mg l^{-1})			BOD (mg l^{-1})			Color absorbance (absorbance m^{-1})									% Color removal		
		JC_{600}	JC_{HNO3}	JC_{KOH}	JC_{600}	JC_{HNO3}	JC_{KOH}	JC_{600}			JC_{HNO3}			JC_{KOH}					
								436 nm	525 nm	620 nm	436 nm	525 nm	620 nm	436 nm	525 nm	620 nm	436 nm	525 nm	620 nm
Sample 1	6.7	175	86	37	21	20	20	84	115	98	65	70	79	53	55	62	44.22	54.55	45.62
Sample 2	8.2	154	78	26	45	35	34	35	63	52	29	58	31	22	44	23	46.35	48.24	58.93
Sample 3	6.4	211	108	59	15	11	11	98	75	51	62	42	36	49	35	31	53.34	62.37	55.08

Moderate color removal was observed for all samples for all three sorbents. In order to fix dyes to the fiber strongly, different type of chemicals used as fixing agents, might be a cause of this moderate percent removal and not only that it could be due to the following factors, (i) interaction between the dyes and other components in the effluents, (ii) change of adsorbent surface due to adsorption and (iii) competition of other components of the effluent for active sites on the carbon surface where displacement effects replace the other components from the adsorption sites.

4.3 Decolorization of textile effluents with increasing adsorbent dosage

To achieve better results like 7, 5 and 3 m^{-1} absorbance at wavelengths of 436, 525 and 620 nm respectively, the dose of adsorbents increased for treatment of three effluents at same contact time of 60 min and obtained values were presented in Table 3 and the corresponding graphs were shown in Figure 3 for three samples. In all cases, it was observed that as the adsorbent dosage increased, the percent removal of color of the effluents also increased.

In sequential operation with JC_{600}, JC_{HNO_3} and JC_{KOH} of sample 1, increase in percent removal from 44.22 to 100

% at 436 nm, 54.55 to 97.53% at 525nm and 45.62 to 98.25 % at 620 nm was observed when the dose increased from 1 to 2 g.

In case of sample 2, the percent removal increased from 46.35 to 95.13 % at 436 nm, 48.24 to 95.30 at 525 nm and 58.93 to 100 % at 620 nm.

In case of sample 3, the percent removal increased from 53.34 to 97.15 % at 436 nm, 62.37 to 100 at 525 nm and 55.08 to 97.11 % at 620 nm observed.

Good response was identified by increasing the adsorbent dosage in decolorization of textile effluents

Table 3: Effect of adsorbents dose in color removal from textile effluents.

Dose (g)	Samples	pH	COD ($mg\ l^{-1}$)			BOD ($mg\ l^{-1}$)			Color absorbance (absorbance m^{-1})									% Color removal		
			JC_{600}	JC_{HNO3}	JC_{KOH}	JC_{600}	JC_{HNO3}	JC_{KOH}	JC_{600}			JC_{HNO3}			JC_{KOH}					
									436 nm	525 nm	620 nm	436 nm	525 nm	620 nm	436 nm	525 nm	620 nm	436 nm	525 nm	620 nm
1	Sample 1	6.7	175	86	37	21	20	20	84	115	98	65	70	79	53	55	62	44.22	54.55	45.62
	Sample 2	8.2	154	78	26	45	35	34	35	63	52	29	58	31	22	44	23	46.35	48.24	58.93
	Sample 3	6.4	211	108	59	15	11	11	98	75	51	62	42	36	49	35	31	53.34	62.37	55.08
1.2	Sample 1	6.7	169	81	35	21	20	20	80	113	96	62	68	75	45	51	60	52.64	57.86	47.37
	Sample 2	8.2	148	76	25	44	34	32	33	62	47	27	57	26	18	42	21	56.10	50.59	62.50
	Sample 3	6.4	206	106	52	14	11	11	97	71	47	61	40	35	45	34	29	57.15	63.45	57.98

1.4	Sample 1	6.7	142	75	31	21	20	18	78	113	93	62	67	75	43	51	60	54.74	57.86	47.37
	Sample 2	8.2	115	70	24	44	32	32	32	62	46	27	57	26	17	41	21	58.54	51.77	62.50
	Sample 3	6.4	186	98	49	14	11	11	96	70	45	61	40	34	45	34	28	57.15	63.45	59.43
1.6	Sample 1	6.7	136	71	25	17	16	14	74	111	89	58	65	71	35	48	58	63.16	60.34	49.13
	Sample 2	8.2	114	65	23	29	27	25	31	58	41	25	55	24	16	38	20	60.98	55.30	64.29
	Sample 3	6.4	176	95	45	14	11	11	95	67	44	58	35	32	41	30	27	60.96	67.75	60.87
1.8	Sample 1	6.7	98	39	18	12	9	7	40	85	83	35	56	65	25	45	41	73.69	62.81	64.04
	Sample 2	8.2	75	52	19	17	15	14	25	42	25	12	36	19	11	25	17	73.18	70.59	69.65
	Sample 3	6.4	112	74	22	11	8	6	47	67	31	31	40	19	28	28	18	73.34	69.90	73.92
2	Sample 1	6.7	75	35	12	9	7	6	15	52	41	11	16	18	0	3	2	100.00	97.53	98.25
	Sample 2	8.2	52	26	8	12	11	9	10	25	12	8	11	9	2	4	0	95.13	95.30	100.00
	Sample 3	6.4	45	31	11	11	7	4	31	45	16	4	12	8	3	0	2	97.15	100.00	97.11

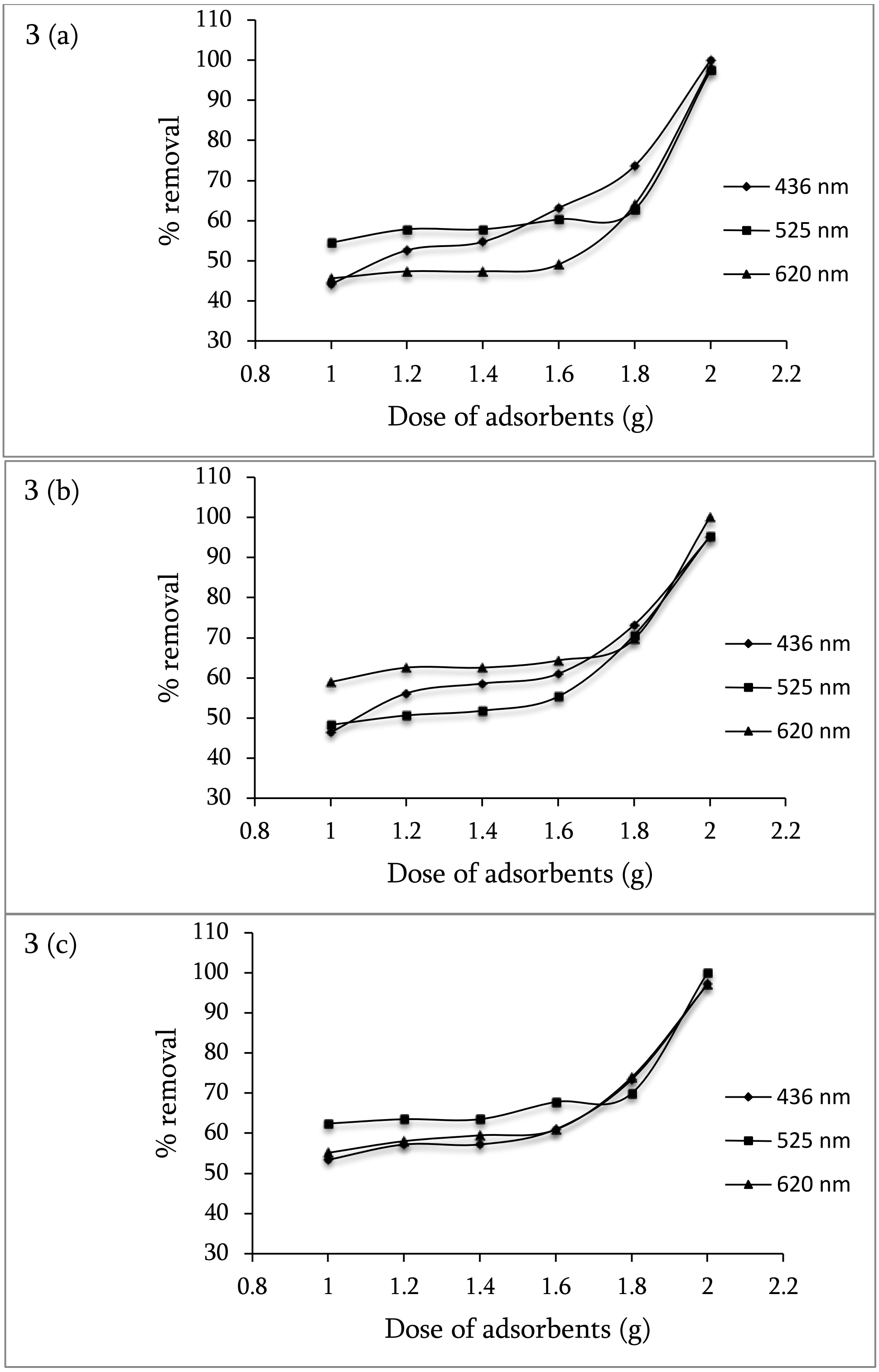


Figure 3(a): Effect of adsorbents dose in color removal from sample 1.

Figure 3(b): Effect of adsorbents dose in color removal from sample 2.

Figure 3(c): Effect of adsorbents dose in color removal from sample 3.

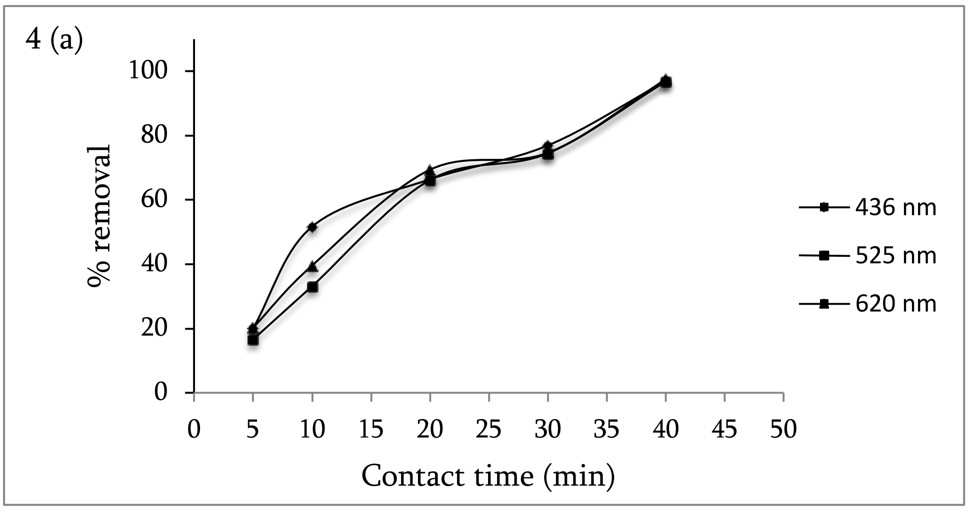
4.4 Decolorization of textile effluents with increasing adsorbent dosage

To find the optimum contact time of adsorbents for removal of color from textile effluents to their permissible value, the same experiment was done by increasing the agitation time with fixed adsorbent dose (2 g). The observed values were tabulated in Table 4 and the corresponding graphs were shown in Figure 4 for three samples.

Table 4: Effect of contact time of adsorbents in color removal from textile effluents.

Time (min)	Samples	pH	COD (mg l^{-1})			BOD (mg l^{-1})			Color absorbance (absorbance m^{-1})									% Color removal		
			JC_{600}	JC_{HNO3}	JC_{KOH}	JC_{600}	JC_{HNO3}	JC_{KOH}	JC_{600}			JC_{HNO3}			JC_{KOH}					
									436 nm	525 nm	620 nm	436 nm	525 nm	620 nm	436 nm	525 nm	620 nm	436 nm	525 nm	620 nm
5	Sample 1	6.7	289	196	124	42	31	29	89	116	109	81	107	99	76	101	91	20.00	16.53	20.18
	Sample 2	8.2	231	168	142	61	48	35	40	79	51	36	71	48	35	68	46	14.64	20.00	17.86
	Sample 3	6.4	389	271	252	24	22	19	102	90	65	97	87	59	85	71	53	19.05	23.66	23.19
10	Sample 1	6.7	251	174	115	31	25	21	71	105	98	62	98	76	46	81	69	51.58	33.06	39.48
	Sample 2	8.2	201	168	117	40	29	32	32	74	46	25	62	44	23	51	38	43.91	40.00	32.15
	Sample 3	6.4	332	241	176	23	18	14	96	86	61	82	81	56	70	68	49	33.34	26.89	28.99

20	Sample 1	6.7	176	102	93	28	18	12	56	96	89	41	78	68	32	41	35	66.32	66.12	69.30
	Sample 2	8.2	163	156	98	38	21	16	28	70	41	21	55	39	18	36	28	56.10	57.65	50.00
	Sample 3	6.4	210	168	111	21	16	11	82	81	52	59	70	48	46	51	35	56.20	45.17	49.28
30	Sample 1	6.7	124	85	71	26	18	11	41	79	87	35	62	65	22	31	29	76.85	74.39	74.57
	Sample 2	8.2	131	123	86	34	21	16	21	64	32	18	46	25	11	26	18	73.18	69.42	67.86
	Sample 3	6.4	182	114	86	19	14	11	58	76	43	41	68	31	34	44	26	67.62	52.69	62.32
40	Sample 1	6.7	81	38	14	9	8	8	18	61	51	15	25	21	3	4	3	96.85	96.70	97.37
	Sample 2	8.2	56	27	11	13	11	8	15	32	18	11	19	15	4	5	2	90.25	94.12	96.43
	Sample 3	6.4	51	35	15	14	12	9	36	48	22	21	26	14	7	2	3	93.34	97.85	95.66



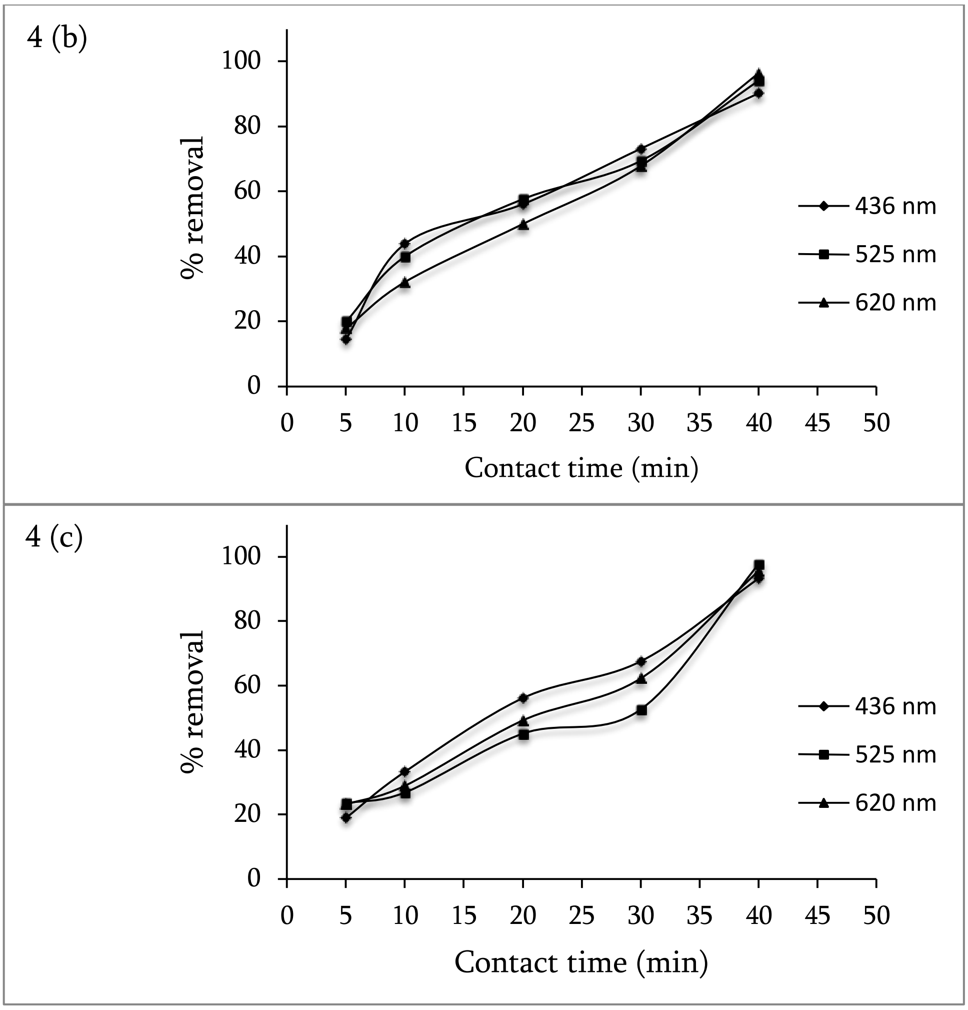


Figure 4(a): Effect of contact time of adsorbents in color removal from sample 1.

Figure 4(b): Effect of contact time of adsorbents in color removal from sample 2.

Figure 4(c): Effect of contact time of adsorbents in color removal from sample 3.

It was noticed that in all adsorption systems the dye removal was increased with increase in agitation time and reached equilibrium within 40 min. The observed percent removal of sample1, 2, and 3 were 97.37, 96.43 and 95.66% respectively.

5. Conclusion:

All the collected effluents were highly colored and prior treatment was always necessary before discharging. The prepared activated carbons successfully removed the color of the effluents. It was observed that besides removal of color, there was concurrent reduction of COD and BOD of the effluents. The effluents treated until the acceptable limit of 7, 5 and 3 m^{-1} absorbance reached at the standard wavelengths of 436, 525 and 620 nm respectively within 40 min and by using 2 g of each adsorbent.

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