**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 effluent 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. 2g of each adsorbent and at optimum contact time of 40 min removed 93% of colour 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]. 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 dyebath 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.

*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****) Effluents discarded to water outlet (shown with arrow) (****g****) Effluents sent out to near-by water bodies (****h****) Different fabric made on the day of sample collection*

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 105oC. This dried waste was then cut into small pieces. It was mixed with K2CO3 solution in in 1:1 ratio and was carbonized in uniform nitrogen flow 600oC. The heating was provided at rate of 10oC 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 JC600. In order to introduce different functional groups, JC600 was divided into two parts. One part was subjected to liquid phase oxidation with 0.1N HNO3 and the other part was soaked in 0.1N KOH for 3 hr and evaporated at 110oC. Both carbons were washed with distilled water until filtrate showed neutral pH. These carbons were dehydrated in an oven overnight at 105oC and named as ‘JCHNO3’ and ‘JCKOH’, 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±2oC). Textile effluents were directly taken without prior filtration. The flasks, along with test solution and 1g 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 JC600 and the solution was filtered, the filtrate was treated with JCHNO3 adsorbent for 1 hr. It was then filtered and finally similar process was also followed with JCKOH 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].

The color intensity of the sample was expressed as absorption coefficient calculated from the equation

COD and BOD analysis was performed using American Public Health Association method [8].

4 Results and discussion**:**

*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**)** | **Oil and grease**  **(**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 |

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*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 JC600, JCHNO3 and JCKOH 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.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *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 | | |
|  | JC600 | JCHNO3 | JCKOH | JC600 | JCHNO3 | JCKOH | JC600 | | | JCHNO3 | | | JCKOH | | |
|  |  |  |  |  |  |  |  | 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 JC600, JCHNO3 and JCKOH 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 2g.

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.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *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 | | |
|  | JC600 | JCHNO3 | JCKOH | JC600 | JCHNO3 | JCKOH | JC600 | | | JCHNO3 | | | JCKOH | | |
|  |  |  |  |  |  |  |  |  | 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 | | |
|  |  |  | JC600 | JCHNO3 | JCKOH | JC600 | JCHNO3 | JCKOH | JC600 | | | JCHNO3 | | | JCKOH | | |
|  |  |  |  |  |  |  |  |  | 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 2g of each adsorbent.

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