Removal of dyes from textile effluent using fruits and vegetable peels as efficient biosorbents

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Abstract— *Color removal from effluents polluted with dyes of textile industries has been considered a challenge due to the difficulty faced in treating such wastewaters. Natural materials such as polysaccharides have gained attention due to their peculiar properties such as being biocompatible, biodegradable, renewable and non-toxic. Due to these properties they are used as efficient bio sorbents. In this study carbonized bio peels of fruits and vegetable were used as simple adsorbents for removal of dyes. These materials were also evaluated for different pH, dye concentration, particle size and contact time of adsorbent for the removal of dyes from wastewater. Experiment results have shown that on decreasing the concentration of dyes along with increase in contact time the dye removal from bio char was more effective. The study is the preliminary effort for use of carbonized bio peel for removal of colorants in effluent waters.*

Keywords—dyes, bio peels, carbonization, adsorption.

1. Introduction

Water is fundamental to the existence and maintenance of life and for this, it must be present in the environment in appropriate quantity and quality. But the water pollution is the one of the major problems arising globally [1]. Water is being used as universal solvent in many industrial processes. Effluents from these industries causes' serious aquatic disturbances and the increased pollution index due to these effluents have degraded human life [2, 3]. Textile industry is one of major industrial sector which release huge amount of organic dyes, heavy metals ions and other toxicants in water bodies [4]. Dyes are widely used in Textile industries which makes the textile effluents colored. Due to high stability of dyes, the color is difficult to remove [5]. The dyes present in the industrial effluent contain high BOD, COD value, toxic compounds, color and other suspended particles which causes health hazard [6]. Dyes, besides affecting the aesthetic value of water bodies, interfere with the penetration of sunlight into the aquatic environment and reduce the light penetration in water bodies [7] hence decreasing photosynthesis of aqueous flora. These dyes may cause allergy, skin irritation, defective eyesight and cancer in humans and animals [8]. It is difficult to find a single effective method which can be used to remove harmful chemicals present in the industrial effluent. The color removal methods which are currently used are coagulation [9], flocculation, ultra-filtration [10] and Nano filtration. These methods being expensive, non-ecofriendly and are used only in large scale [11]. Compared to the above conventional methods for removal of color from water, use of biosorbents could be advantageous owing to

the low cost, ready availability, environment friendly and high efficiency [12,13]. The adsorption of dyes on various types of materials has been studied in detail. The effective adsorption mechanism can be seen in biochar. Biochar is a potential adsorbent material that is a carbon rich form of charcoal produced by pyrolysis i.e heating under limited oxygen conditions from the waste biomass of fruits and vegetable peels [14]. The biochar obtained from the banana peels [15,18], orange peels [16], coconut coir [17], cucumber peels, potato peels [18] and apple peels etc. are efficient in removing dyes from industrial effluents. All fruits and vegetable peels contain polar functional groups such as -OH, $-NH_2$, and -COOH on the surface. The biochar is often produced with very small surface area, pore volume and the functional groups could afford primary adsorptive forces between the adsorbent and adsorbate [19]. Working parameters like dose of adsorbent, concentration of dye, particle size [20] and contact time were used to calculate the percentage removal of dye.

2.Materials and Method

2.1 Sample and Adsorbent collection

Fruits and Vegetable peel were used as the adsorbents which were collected from the juice shop and home. Samples of dye was prepared using different concentration of Methyl Red which is used as azo dye, purchased from ASES chemicals.

2.2 Preparation of Adsorbent

The biopeels of fruits and vegetables such as banana peels, orange peels, coconut coir, cucumber peels, potato peels and apple peels etc. were cleaned, washed with tap water, chopped, dried in sunlight, distilled washed, oven dried, carbonized, grinded, dried properly and sieved. The process of carbonization was performed in mechanical foundry of JIET Jodhpur in a muffle furnace at a temperature of 600-700 for one hour . The ready material was crushed using a pestle and mortar in civil engineering department of JIET, Jodhpur. Finally, different mesh sizes of the Sieves were used to obtain the different particles sizes of the grinded material for the experimental work. The mesh sizes of 300µm, 150µm and 75µm were used in this study.

2.3 Preparation of Standard solutions

Methyl Red is a reactive Azo dye which is very commonly used in textile industries. The Reactive Red dye was used for the preparation of aqueous solution. The dye was obtained from ASES Chemicals. Aqueous solution of dye with different concentration was prepared and used in all experiments. The dye solution was prepared by dissolving the different amount of reactive dye in distilled water at various concentrations. Experiments were carried out at concentrations of 25, 50, 75, 100, and 125 mg/l of the dye using the different doses of an adsorbent.

2.4 Batch Adsorption Study

In this experiment effects of different parameters were studied such as amount of Adsorbent, contact time between adsorbent and adsorbate, pH values and effect of different particle size. 10mL of sample was taken and desirable amount of adsorbent was added to it at room temperature. For proper adsorption magnetic stirring of the solutions were performed for each batch for 1 hour. At different intervals the sample were withdrawal and filtered to separate adsorbent from the sample. Using UV spectrophotometer, the absorbance of supernatant solutions was measured.

Percentage removal was calculated using the formula

Percentage removal = [(Ci – Cf) / Ci] × 100

Amount adsorbed = (Ci – Cf)/ m Where, Ci = Initial dye concentration (mg / 1),

Cf = Final dye concentration (mg/ 1), m= Mass of adsorbent (g /1)

3.Result and Discussions

3.1 Effect of Particle Size of adsorbent

The particle size of the adsorbate in adsorption plays important role since the process of adsorption is entirely dependent on the surface area of the adsorbent material. Adsorbent dose was kept constant in each batch. Particle sizes were varied from 300µm, 150µm and 75µm. For different particle sizes, the removal percentages of dye on carbonized biopeels were measured. Table. 1and figure1 represents the results for maximum color removal of dyes using different particle sizes of adsorbent.

Table 1: Effect of Particle Size of adsorbent

Dye Concentration mg/L	Particle Size of Adsorbent		
	300µm	150µm	75µm
25	69	88	92
50	56	69	76
75	40	53	68
100	39	38	57
125	37	36	54

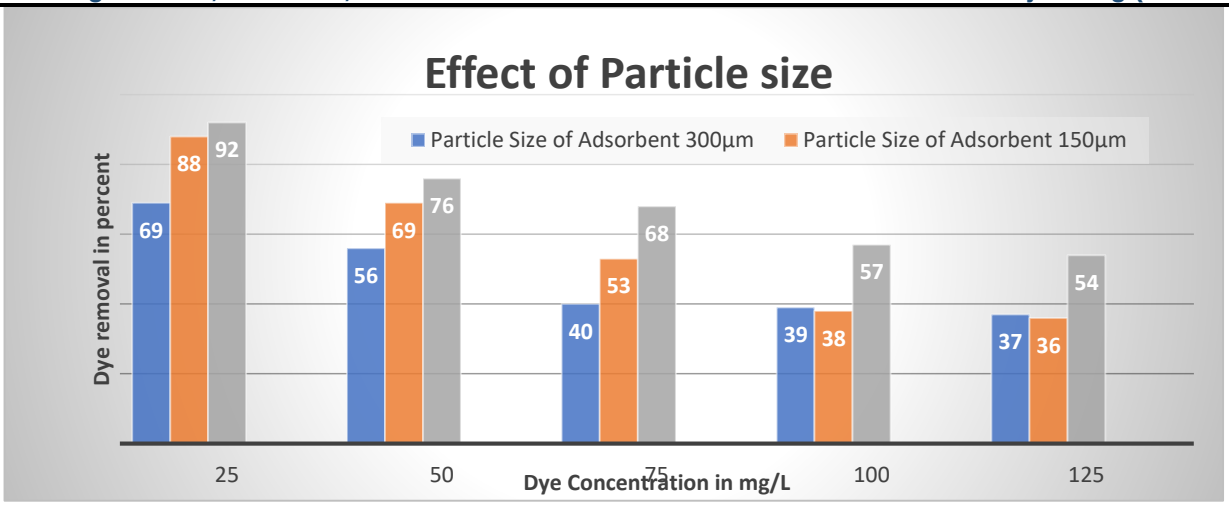

Figure 1: Effect of Particle Size of adsorbent

3.2 Effect of contact time

Contact time was varied from 12-60 hours to analyze the maximum adsorption. The effect of contact time was studied on adsorption process and contact time ranging from 12-60 hours the results as shown in Table 2 and figure 2 indicate that the adsorption decreases with the decrease in contact time and increases with the increase of contact time. The influence of initial dye concentration for the color removal of Methyl Red dye, five initial dye concentrations 25, 50, 75, 100 and 125 mg/L were used with adsorbent dosage 0.5gm/100 ml, particle size 75µm, room temperature and pH 3.0.

Table2 : Effect of Contact time

Contact Time in hours	Dye Concentration mg/L				
	25	**50**	**75**	**100**	**125**
12	43	32	25	24	18.7
24	47	36.5	43	36	31
36	65	55.5	63.4	53	47
48	88.5	82	87	78.5	72
60	94	86.5	89.2	81.6	75

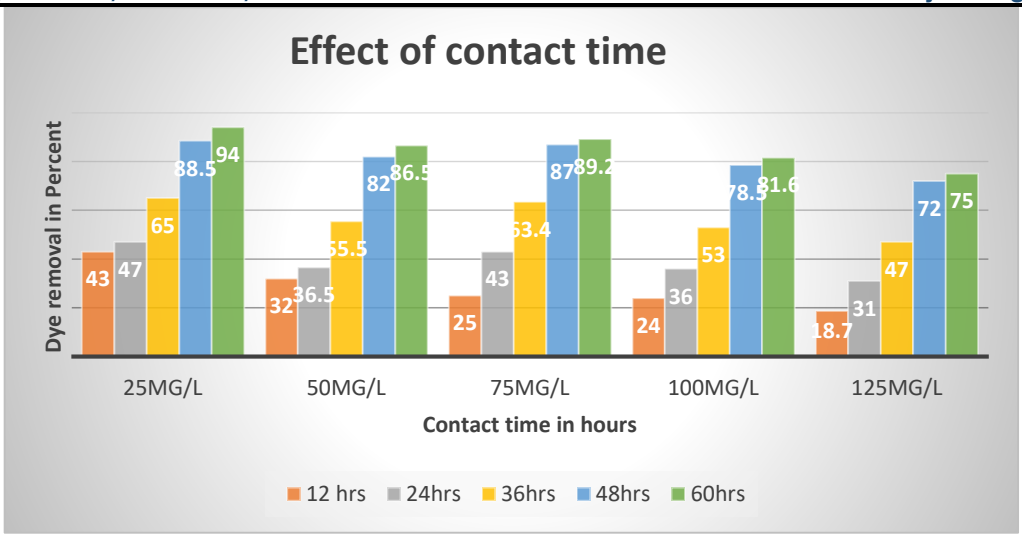

Figure 2: Effect of Contact time

3.3 **Effect of adsorbent dose**

Adsorbent dose plays an efficient role in dye removal. It was seen that when the concentration of dye was 25 mg/L maximum color removed was 57% with a dose of 10g/L and when the dose was increased to 50 g/L percentage of dye removal was also increased up to 93.7%. It is evident from the above results that with the increase in dose of adsorbent the dye removal also increases and vice versa. The results are interpreted in table 3 and figure 3.

Table: 3 Effect of adsorbent dose on percentage of dye removal

Adsorbent Dose g/L	Dye Concentration mg/L				
	25mg/L	50 mg/L	75 mg/L	100 mg/L	125 mg/L
10	57	51	42.6	32.3	23
20	67.4	59	51	39	29.8
30	81	73.5	62.3	51	42
40	86	78	64.7	57	39.7
50	93.7	82	74	63.6	50.5

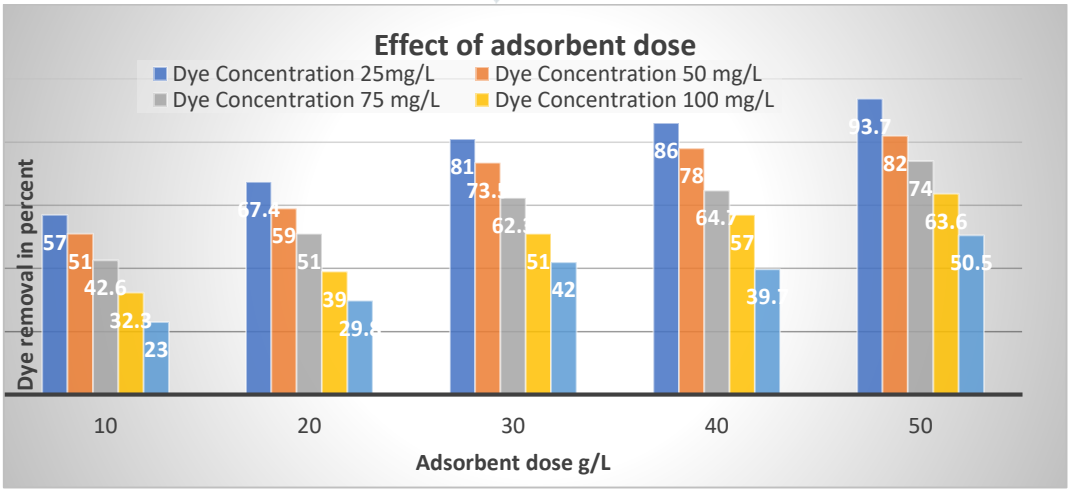

Figure 3: Effect of adsorbent dose

3.4 Effect of pH

The hydrogen ion concentration (pH) primarily affects the degree of ionization of the dye and the surface properties of the adsorbent. These, in turn, lead to alterations in the amount of dye removed in such a way that in pH 7.5 and above the adsorption found to be negligible. But on lowering the pH the dye removal was increased.

4. Conclusion

It was concluded that the percent color removal of Methyl Red dye from aqueous solution by using carbonized biopeels prepared from fruits and vegetables peels increased with the decrease in initial dye concentration, particle size of adsorbent and pH of the solution. However, the dye removal percentage was also increased with increasing dosage of adsorbent and the contact time. It was found that it can remove maximum 92% dye in 25mg/L dye concentration having 75µm particle sizes of adsorbent. Even tough the removal efficiency is not as expected but being environment friendly and less expensive, fruits and vegetable peels can be considered as the alternative step of dye removal.

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