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Removal of Methylene Blue from Aqueous Solution Using Biosorbent

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Abstract

There is a considerable need for the removal of colour from wastewater or effluents. Currently, several physical and chemical processes are used for dyes wastewater treatment. However, these processes are of high cost and not efficient for the treatment of wide range of wastewater. In this study, the waste fruit shell of Limonia Acidissima is used as a biosorbent. The powdered raw material and treated material of specific micron size is used for the removal of the methylene blue from aqueous solution. The applicability of this treated material and raw material as an adsorbent for organic pollutant removal was studied and optimum conditions were evaluated for efficient adsorption of methylene blue. The results show that the removal of dye by chemically treated material is effective than raw material at higher temperature. The percentage removal of dye is maximum at 35^{0}C for treated material and at 25^{0}C for raw material.

Key words: *Limonia Acidissima*, biosorbent, raw material, treated material, methylene blue

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INTRODUCTION

Many industries use dyes in order to colour their products and pour a lot of coloured wastewater into the effluent. The discharge of dye-bearing wastewater into natural streams and rivers from the textile, paper, carpet, leather, distillery and printing industries possesses severe problems. Recently, about 9000 types of dyes have been incorporated in the colour index**.** The wastewater discharged from dying processes is highly coloured, hot, alkaline and contain high amounts of dissolved solids. [**1**] Dyes even in low concentrations affect the aquatic life and food web. Due to low biodegradability of dyes, the discharge of coloured wastewater from these industries damages the environment, as they are carcinogenic and toxic to human and aquatic life. [**2,3**] The discharge of coloured wastes into streams not only affects the aesthetic nature but also interfere with transmission of sunlight into streams and therefore reduce photosynthetic activity. Most of the dyes are very stable either to photo degradation, biodegradation or oxidizing agents.

The removal of dyes from wastewater is of great concern, since some dyes and their degradation products may be harmful and consequently, their treatment cannot depend on biodegradation alone. **[4]**

Dyes laden wastewater is usually treated by physical and chemical processes. These include flocculation, electro-flotation, precipitation, electro-kinetic coagulation, ion exchange, membrane filtration, electrochemical destruction, irradiation and ozonation. However these processes are costly **[5]** and cannot effectively be used to treat the wide range of wastewater containing dyes. Adsorption using activated carbon has been found to be superior to other techniques for wastewater treatment in terms of initial cost, simplicity of design, ease of operation and insensitivity to toxic substances. Activated carbon is a form of carbon that is specially treated to produce a highly developed internal pore structure and a large surface area, thus producing reasonably cheaper and excellent adsorbent**. [6-8]**

Table1: Some low cost materials for dyes removal from aqueous solution

Adsorbent(s)	**Dye(s)**	**References**
Jackfruit peel	Methylene blue	[10]
Jackfruit leaf	Methylene blue	[111
Cotton fibre	Methylene blue	[12]
Sugarcane bagasse	Methyl red	[13]
Rice husk, groundnut shell, coconut shell, Bamboo dust	Methylene blue	[14-15]
Indian Rose Wood Sawdust	Methylene blue	[16]
Oil palm trunk fibre	Malachite green	[17]
Yellow passion fruit peel	Methylene blue	[18]
Rice husk	Malachite green	[19]
Banana pith	Congo red, Rhodamine-B, Procion orange	[20-23]
Guava leaf powder	Methylene blue	[24]
Groundnut shell	Malachite green	[25]
Rice husk	Methylene blue	[26]
Coconut bunch	Methylene blue	[26]
Pumpkin seed hull	Methylene blue	[28]

There is a multitude of industrial applications of activated carbon. Pollution control and wastewater treatment are growing areas of use to combat environmental pollution. **[6-9]** Due to high cost of commercial carbon the economically beneficial agro waste materials are effectively used for the removal of dyes from waste water. Such agro waste materials had been used as adsorbent for dye sorption from wastewater are listed in **Table1.**

The aim of present study was to investigate the optimum conditions for the removal of a cationic dye from aqueous solution by adsorption technique using sulphuric acid treated fruit shell.

MATERIAL AND METHOD

Preparation of adsorbent

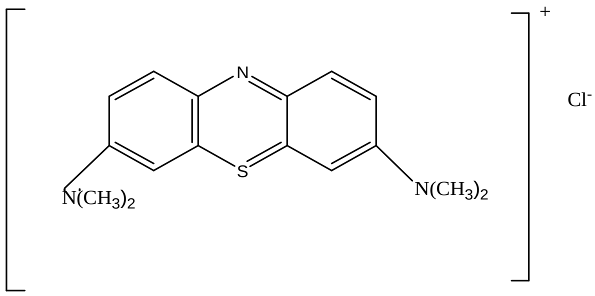
The fruit shell of *Limonia Acidissima* was collected from nearby area of Pune, Maharashtra, India. Material was dried, crushed and powdered raw material (PRM) was obtained, sieved to get uniform size (63 mesh).

The crushed raw material (100g) was treated with A. R. grade concentrated $H_2 SO_4$ (70 ml) and kept in an oven at 120^0C for six hours. The carbonized material was then washed with distilled water to get it free from acid and dried at 105^0C for 18 hours. The dried treated material (TM) was grounded and sieved to get uniform size (63 mesh).

Preparation of dye solution

Methylene blue [3, 9-bis dimethyl-aminophenazo thionium chloride], a cationic dye **(Figure 1)**, was purchased from Merck and used as received without further purification. The stock solution of methylene blue $1x10^{-5}$ M was prepared in distilled water.

Figure1: Methylene blue [3, 9-bis dimethyl-aminophenazo thionium chloride]



Adsorption study:

To evaluate the efficiency of adsorbents, laboratory batch mode studies were conducted at different temperatures. In each adsorption experiment, 50 ml of dye solution of known concentration at initial pH of solution was added into 0.050gm of adsorbent in a 100 ml flask and the mixtures was stirred at 500 rpm on a mechanical stirrer. After predetermined time intervals, adsorbent was separated from solution by filtration method. The absorbance of the supernant solution was estimated to determine the residual dye concentration at 660 nm with Spectrophotometer (EQ-650- A EquipTronics).

RESULTS AND DISCUSSION

In case of treated material percent removal of methylene blue from aqueous solution is maximum as compared to powdered raw material. Increase in percent removal for treated material is due to increase in activation by treating it with an acid. In powder raw material results show that as temperature increases, percent removal of methylene blue from aqueous solution decreases. This indicates physisorption process. In treated material results show that percent removal first increases and then decrease with increases in temperature. This indicates chemisorption process. The results are summarized in **Tables and Figures 2- 4**.

Table 2: Effect of adsorbent on dye removal at 1x10^{-5} M conc. of methylene blue at 25^{0}C (Adsorbent dose=0.050g/50ml at initial pH of solution)

Time in minutes	% Dye Removal using PRM	% Dye Removal Using TM
2	2.56	31.00
4	23.08	31.00
6	48.73	26.00
8	23.32	44.00
10	61.55	67.00
15	76.94	44.00
20	69.24	80.00
25	71.81	59.00
30	87.20	80.00
60	94.89	87.00
120	71.81	74.00

Graph: Effect of adsorbent on dye removal at 25^{0}C

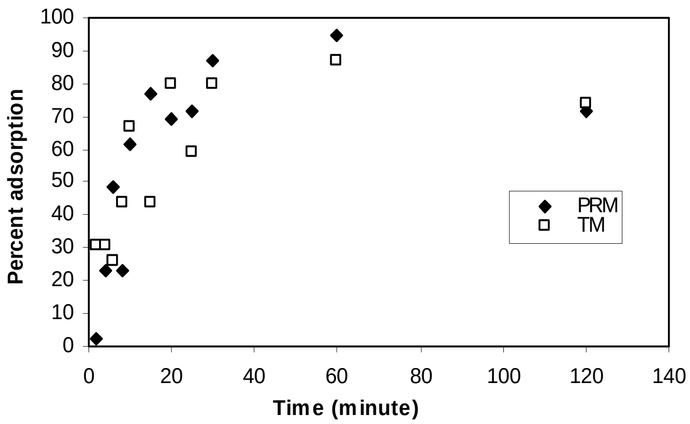


Figure.2.Effect of adsorbent at 25 ^{0}C

Table 3: Effect of adsorbent on dye removal at $1x10^{-5}$ M conc. of methylene blue at 35^0C (Adsorbent dose=0.050g/50ml at initial pH of solution)

Time in minutes	% Dye Removal using PRM	% Dye Removal Using TM
2	16.39	44.27
4	8.199	59.03
6	20.00	65.59
8	16.39	78.71
10	24.59	77.07
15	37.71	80.34
20	49.19	83.62
25	40.99	81.98
30	40.99	75.42
60	54.11	80.34
120	63.95	88.54

Graph: Effect of adsorbent on dye removal at 35^0C

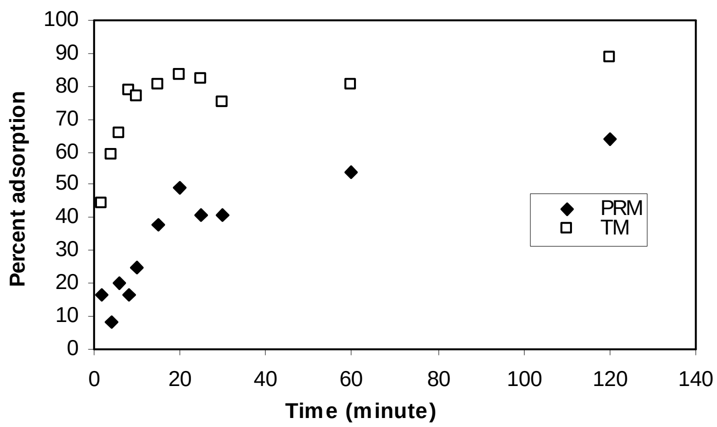


Figure.3.Effect of adsorbent at 35 ^{0}C

Table 4: Effect of adsorbent on dye removal at $1x10^{-5}$ M conc. of methylene blue at 45^0C (Adsorbent dose=0.050g/50ml at initial pH of solution)

Time in minutes	% Dye Removal using PRM	% Dye Removal Using TM
2	10.34	31.04
4	12.07	55.14
6	13.84	56.91
8	18.97	62.08
10	15.52	63.81
15	25.86	63.81

20	25.86	67.25
25	29.31	60.36
30	27.59	63.81
60	44.83	62.08
120	36.21	56.91

Graph: Effect of adsorbent on dye removal at 45^{0}C

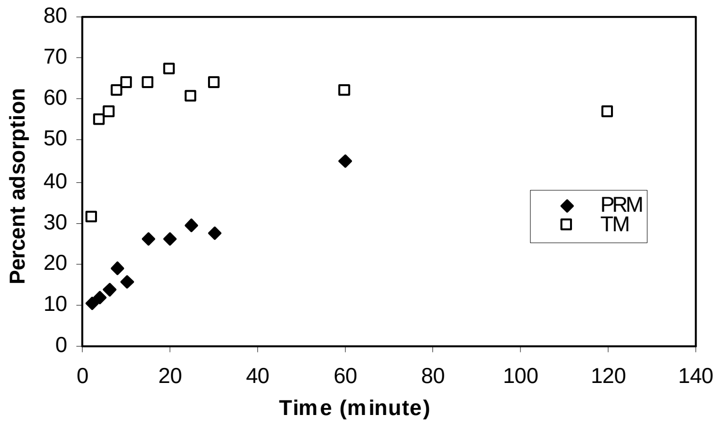


Figure.4.Effect of adsorbent at 45 ^{0}C

CONCLUSION

Temperature dependence of adsorption process is a complex phenomenon. Thermodynamic parameters, like heat of adsorption and energy of activation play an important role in predicting the adsorption behavior and both are strongly dependent on temperature. Temperature rise affects the solubility and chemical potential of the adsorption, the latter being a controlling factor for adsorption. The result shows that the removal of dyes by chemically treated material is effective than raw material at higher temperature. The percentage removal of dye is maximum at 35^{0}C for treated material and at 25^{0}C for raw material.

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