Research Article

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Removal of Cationic Dye from effluents using Eco-Friendly Adsorbent

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ABSTRACT

In the present study, the use of cheap, ecofriendly and abundantly available waste weed as a raw material for producing adsorbent is investigated. *Achyranthes aspera* Linn. plant is widespread in the world as a weed, which is locally available on road sides and wastelands. The main aim of this study is to investigate the potentiality of *Achyranthes aspera* Linn stem as an adsorbent for the adsorption of malachite green. The powdered raw material and chemically treated material of specific micron size is used for the removal of the malachite green from aqueous solution. Adsorption capacity is studied by using malachite green as dye at various temperature. The results revealed that the removal of dye by chemically treated material is more effective than raw material at higher temperature. The experimental data is analyzed using Freundlich and Langmuir isotherm models and it is fit with these isotherm models. The adsorption capacities (Q_m) are calculated as 27.4, 29.7, 28.3 at 25,35 and45^{0}C respectively . It can be useful as low cost, efficient, potential and ecofriendly adsorbent for the treatment of effluents.

Key words: *Achyranthes aspera* Linn., malachite green, adsorption, adsorption isotherms.

INTRODUCTION:

World wide over 7x10^5 tones of dyes and pigments are produced annually. Dyes are used in large quantities in many industries including textile, leather, cosmetics, paper, printing, plastic, pharmaceuticals, food etc. to color their products, which generates waste water, characteristically high in colour and organic content [1,2].

Due to low biodegradability of dyes, the discharge of coloured waste water from these industries damages the environment, as they are carcinogenic and toxic to human and aquatic life [3,4].Activated Carbon has been widely used as an adsorbent for separation, purification, decolorization , deodorization of vegetable oils and fats, water purification and pollution treatment[5-7] .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 **Table 1.**

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Table 1: Some low cost materials for dyes removal from aqueous solution

Adsorbent(s)	Dye(s)	References
Jackfruit Peel	Methylene blue	[8]
Jackfruit leaf	Methylene blue	[9]
Cotton fiber	Methylene blue	[10]
Sugarcane bagasse	Methyl red	[11]
Rice husk, groundnut shell, Coconut shell, Bamboo dust	Methylene blue	[12, 13]
Indian Rose wood sawdust	Methylene blue	[14]
Oil palm trunk fiber	Malachite green	[15]
Yellow passion fruit peel	Methylene blue	[16]
Rice husk	Malachite green	[17]
Banana pith	Congo red, Rhodamine-B, Procion orange	[18-21]
Guava leaf powder	Methylene blue	[22]
Groundnut shell	Malachite green	[23]
Rice husk	Methylene blue	[24]
Coconut bunch	Methylene blue	[25]
Pumpkin seed hull	Methylene blue	[26]

Adsorption on activated carbon has been proven to be very effective in removing dyes from aqueous solutions. Currently the research is focused on the development of low-cost adsorbents. Natural adsorbents are attractive because of their abundant availability at low cost and their good performance in removing dyes from aqueous solutions. Use of waste weed as raw material for producing activated carbon for removal of malachite green from aqueous solution was investigated in this work.

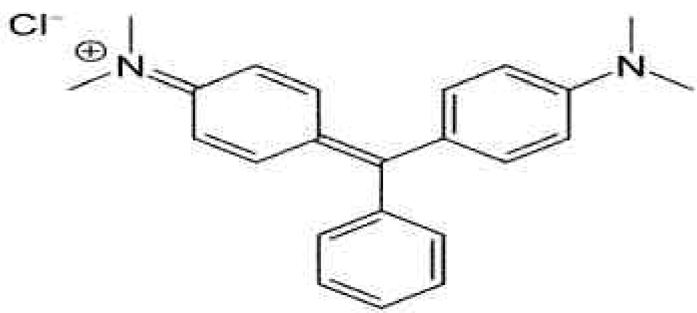
MATERIALS AND METHODS :

Preparation of adsorbent :

The plant material was collected from the Purander district of Pune, Maharashtra, India. It was authenticated form Botanical survey of India, Pune, Maharashtra, India. The air shade dried and pulverized stem material of *A. aspera* was used. The raw material (100g) was charged with A. R. grade concentrated H_2SO_4 (35 ml), which was charred and kept in an oven at 100-110^{0}C for six hours for complete carbonization. The carbonized material was washed with distilled water to get free from acid and dried at 110^{0}C for six hours. The dried material was grounded and sieved to get uniform particle size (63 mesh).

Preparation of dye solution

Malachite green(M.F : $C_{23}H_{25}ClN_2$, M.Wt : 364.911 g/mol), a cationic dye was purchased from Merck .The stock solution of malachite green 1x10^{-5} M was prepared in distilled water.



4-[(4-dimethylaminophenyl)phenyl-methyl]-*N*,*N*-dimethylaniline

Adsorption study:

Batch adsorption studies:

The adsorption capacity of a dye depends on the temperature employed. Thus, the adsorption equilibrium uptake of dye solutions were investigated by employing different temperatures for powdered raw material (PRM) and activated carbon (AC).

Effect of temperature :

In each adsorption experiment, 0.050gm of adsorbent was added into 50 ml of dye solution of 1x10^{-5} M concentration at pH-9.4 of solution in a 100 ml flask and the mixture was stirred at 500 rpm on a mechanical stirrer for different intervals of times. 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 Digital colorimeter (EQ-651-A EQUIP- TRONICS).

The proportion of dye removed from solution were calculated from $(C_o - C_e)$

Where, C_o and C_e are the initial and equilibrium concentration of dye respectively. The amount of adsorbed dye per unit mass of adsorbent q_e (mg/g) was calculated by the equation :

$$q_e = (C_0 - C_e) V / W$$

Where, C_o and C_e (mg/L) : The initial and equilibrium concentration of dye

V (L) : The volume of the solution

W (g) : The weight of adsorbent used

The removal percentage of dye was calculated as follows

$$\% \text{ Removal of dye} = C_0 - C_e / C_0 \times 100$$

RESULTS AND DISCUSSION :

The percent removal of malachite green from aqueous solution of activated carbon is maximum as compared to powdered raw material. In powder raw material results reveals that, as temperature increases, percent removal of malachite green from aqueous solution decreases. This indicates physisorption process. The activated carbon show that percent removal first increases and then decrease with increases in temperature. This indicates chemisorption process.

The results are summarized of powdered raw material (RM) and activated carbon (AC) at 25^{0}C, 35^{0}C, 45^{0}C in (**Tables 2,3&4)**. The data is shown by the graphs **(Figures 1,2)**.

Table 2: Effect of adsorbent on dye removal at 1x10^{-5} M conc. at 25^{0}C

Time in minutes	% Dye Removal using RM	% Dye Removal Using AC
2	46.24	37.45
4	49.67	40.23
6	54.84	41.36
8	57.26	48.53
10	60.74	53.27
15	65.13	64.14
20	71.28	66.27
25	73.19	75.45
30	73.51	83.68
60	79.12	84.54
120	78.29	84.23

(Adsorbent dose=0.050g/50ml at pH-9.4)

Table 3: Effect of adsorbent on dye removal at 1x10^{-5} M conc. at 35^{0}C

Time in minutes	% Dye Removal using RM	% Dye Removal Using AC
2	22.82	58.62
4	25.67	59.34
6	30.04	64.23
8	32.22	71.34
10	35.14	77.53
15	41.39	80.67
20	44.09	84.80
25	49.27	86.05
30	50.82	88.56
60	59.67	94.50
120	58.03	94.00

(Adsorbent dose=0.050g/50ml at pH-9.4)

Table 4: Effect of adsorbent on dye removal at $1x10^{-5}$ M conc. at 45^0C

Time in minutes	% Dye Removal using RM	% Dye Removal Using AC
2	15.82	48.14
4	16.23	49.23
6	18.64	49.54
8	21.34	52.67
10	26.21	56.33
15	30.41	67.27
20	33.41	69.18
25	35.14	78.56
30	40.24	84.67
60	45.64	88.23
120	44.16	88.12

(Adsorbent dose=0.050g/50ml at pH-9.4)

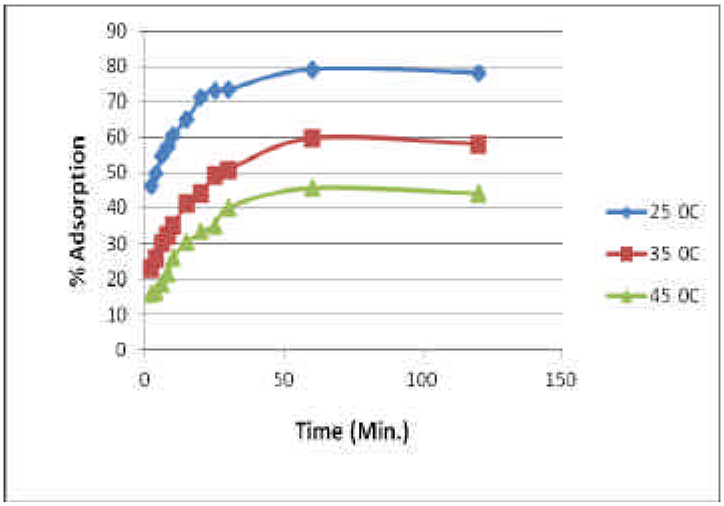


Figure. 1. Effect of Temperature on % Adsorption of RM

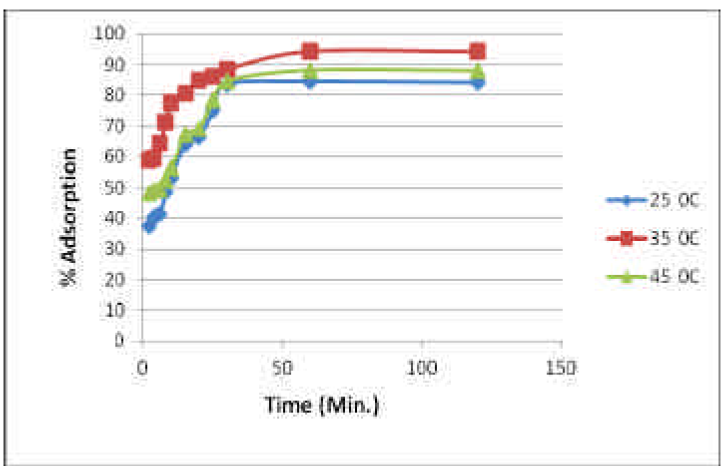


Figure. 2 Effect of Temperature on % Adsorption of AC

Adsorption Isotherm :

The experimental data are analyzed by the linear form of the Freundlich and Langmuir isotherms [27,28].

A] Freundlich isotherm :

The linear form of Freundlich isotherm is represented by the equation : $\log q_e = \log K_f + 1/n \log C_e$

where,

q_e : The amount of dye adsorbed per unit mass of adsorbent at equilibrium (mg/g)

C_e : The equilibrium concentration of dye in solution (mg/L)

K_f and n : Freundlich Constants incorporating the factors affecting the adsorption capacity and intensity of adsorption respectively.

Linear plots of log q_e versus log C_e indicates that the adsorption of dye obey the Freundlich adsorption isotherm (**Figure. 3)**.

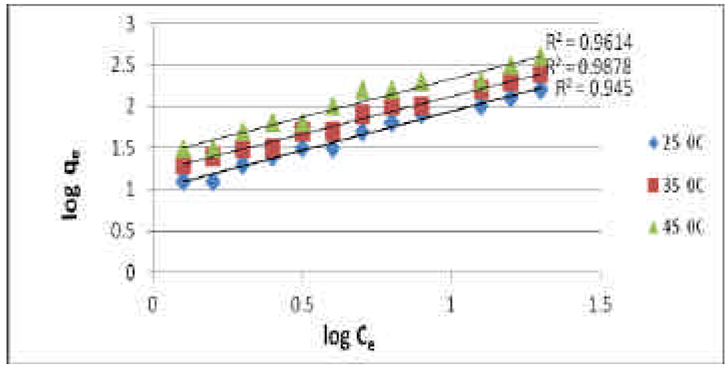


Figure. 3 Freundlich isotherm for the adsorption of malachite green

Table 5 : Freundlich isotherm

Temp. (^0C)	Kf (mg/g)	n	R^2
25^0C	16.4	1.7	0.945
35^0C	17.9	1.9	0.987
45^0C	15.7	1.6	0.961

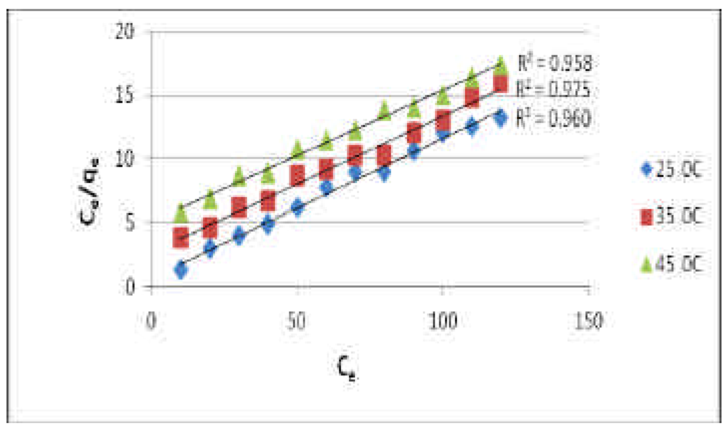


Figure. 4 Langmuir isotherm for the adsorption of malachite green

Temp. (^0C)	Q_m(mg/g)	b (L/mg)	R^2
25^0C	27.4	0.53	0.960
35^0C	29.7	0.67	0.975
45^0C	28.3	0.42	0.958

The values of n>1 and correlation coefficient R^2 obtained from linear plot of Freundlich and Langmuir isotherm models are very close to unity which indicates that the applicability of these models. This indicates that malachite green dye is favorably adsorbed by activated carbon.

CONCLUSION:

This adsorbent is found to be effective and economically attractive. It could be used as a cheap substitute of commercially available adsorbents for decolorizing of industrial effluents.

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