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Plant poisoning brilliant green dye adsorption on sawdust from aqueous solution and its recovery

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ABSTRACT

The organic dye pollution directly affects the soil, water and plants. The plant poisoning effect had been studied by the adsorption of cationic Brilliant green dye on raw sawdust from aqueous solution. The sawdust is a cellulose material (basic surface). The dye adsorption on the basic surface is correlated with experimental conditions. The experimental conditions like contact time, concentration of dye solution, temperature, dosage of adsorbent and particle size were optimized for maximum uptake and observed that the adsorption increased with increase of contact time (6h), temperature(30-70ºC) and dosage of the adsorbent. The concentration effect was studied from 100 to 500ppm and observed that the percentage of adsorption decreased with increase of dye concentration. The adsorption increased with decrease of particle size (0.6-1.0mm). The recovery of the dye was studied in water, methanol and ethanol. The desorption tendency of dye is in the increasing order of water (5%)<methanol (54%)<ethanol (64%). Ethanol is the best solvent for the recovery of brilliant green from sawdust. The poor desorption of brilliant green in water proved that the strong adsorption of cationic brilliant green on the basic active sites of cellulose (sawdust). Hence, it is a plant poisoning organic dye.

KEYWORDS

Plant poison;
Brilliant green;
Sawdust;
Adsorption;
Recovery.

INTRODUCTION

Dye wastewater from textile dyeing and dye manufacturing industries causes serious pollution problems because of its high color and organic content. The dye effluent discharged into water bodies like lakes, rivers, etc. affects the aquatic flora and fauna, and causes many water borne diseases[1]. Since synthetic dyes are complex aromatic compounds, they are more stable and more difficult to biodegradation[2,3]. Today there are more than 10,000 dyes available commercially[4]. The annual production of dyes worldwide is around 7×10^5 tonnes, 5-10% of which is discharged into water bodies as effluents[5]. Therefore, good waste treatment methods are necessary to save environment from dye pollution. The conventional methods for treating dyecontaining wastewater like coagulation, flocculation, adsorption, oxidation, photochemical destruction, ion exchange and membrane filtration[6] are costly and require some additional chemicals. Hence, these methods are not much suitable to treat organic dye effluents. The adsorption methods have been widely used for removal of colorants from wastewater. Adsorbents like activated carbon[7], natural zeolites[8], Sawdust[9], fly ash[10], molecular sieves[11,12] and agricultural wastes[13] have been used for dye removal.

In this present work, adsorption of cationic Brilliant green (BG) has been studied using sawdust as an adsorbent. BG is an important dye used for dyeing wool, silk, leather, cotton, jute, etc. {The adsorption study of BG is important because of the toxicity of the dye to living organisms and plants.} Adsorption of BG was already studied using rice husk ash[13], Bagasse fly ash[14], Neem leaf powder[15], modified peat–resin particle[16]. The peat resin is modified with chemical treatments make environmental pollution and highly expensive, the rice husk ash and Bagasse fly ash are cheap material but their adsorption capacity was poor. Hence, in the present investigation, the attempts are made to adsorb BG on sawdust for maximum adsorption without any pretreatment of sawdust. Moreover, generally plants are made up of cellulose materials (basic surface). These cellulose materials are affected by strong adsorption of cationic organic dyes, which are strong poison to plants. Hence, it becomes important to study the plant toxic nature of the dye. In this view, the cationic BG adsorption was carried out on sawdust to evaluate the plant toxic nature of the dye.

EXPERIMENTAL

The dye BG supplied by Merk India Ltd. was used for adsorption studies on sawdust. The structure of BG is given in SCHEME 1. BG-Molecular formula $C_{27}H_{34}N_2O_4S$, Molecular Weight 482.65, C.I. No. 42040 and λ_{max} 628-632nm.

Sawdust activation

Mango sawdust collected from saw mill was sieved into different particle sizes and then they were washed with deionised water and dried in hot air oven at 120°C for 2 hours.

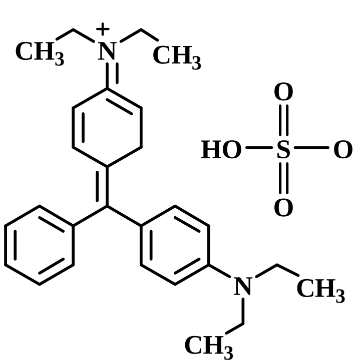
Adsorption studies

The bg stock solution 1000ppm was prepared by dissolving 1g of dye in 1 litre of double distilled water in a standard measuring flask. The working solutions of the desired concentration were prepared by successive dilution of the stock solution. The dye concentration was analyzed bg UV–Visible spectrophotometer (Elico- model-SL171).

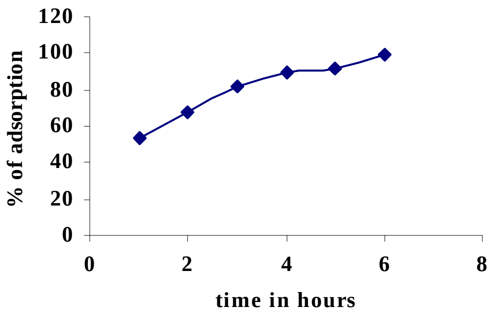
200mg of the activated sawdust was added with 50ml of dye solution in 100ml conical flask. The solution was stirred in a Magnetic stirrer(Remi-Model MLH), at the end of the experiment the solutions were centrifuged off. The final concentration of the solution was measured spectrophotometrically at λ_{max}630nm. The contact time was studied up to 6 hours to find out the equilibrium adsorption. The adsorption process of BG on sawdust is studied in the concentration range of 100-500mg/l. The initial and final pH values were measured for all concentration by using pH meter (Elico-model LI 613). The temperature effect of BG adsorption on sawdust was studied in the range of 30-70ºC. The sawdust dosages were studied in the range of 200-1000mg.

Desorption studies

5mg BG adsorbed on 200mg of sawdust was used in the desorption studies. The BG adsorbed sawdust 200mg was added with 50ml of solvents like ethanol, methanol and water separately in 100ml conical flask. The solution was stirred for 1 hour at room temperature in a Magnetic stirrer (Remi-Model MLH), at the end of the experiment the solutions were centrifuged off. The final concentration of the solution was measured spectrophotometrically at λ_{max}630nm.



SCHEME 1 : Structure of brilliant green



Temperature 30° C, concentration 100ppm, Dosage 200mg, particle size 0.6mm

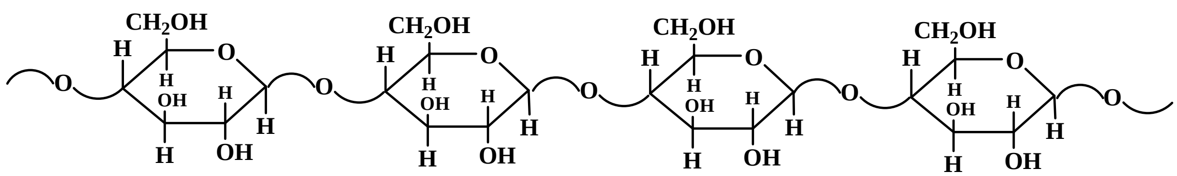
Figure 1: Effect of contact time for the uptake of brilliant green on sawdust

RESULT AND DISCUSSION

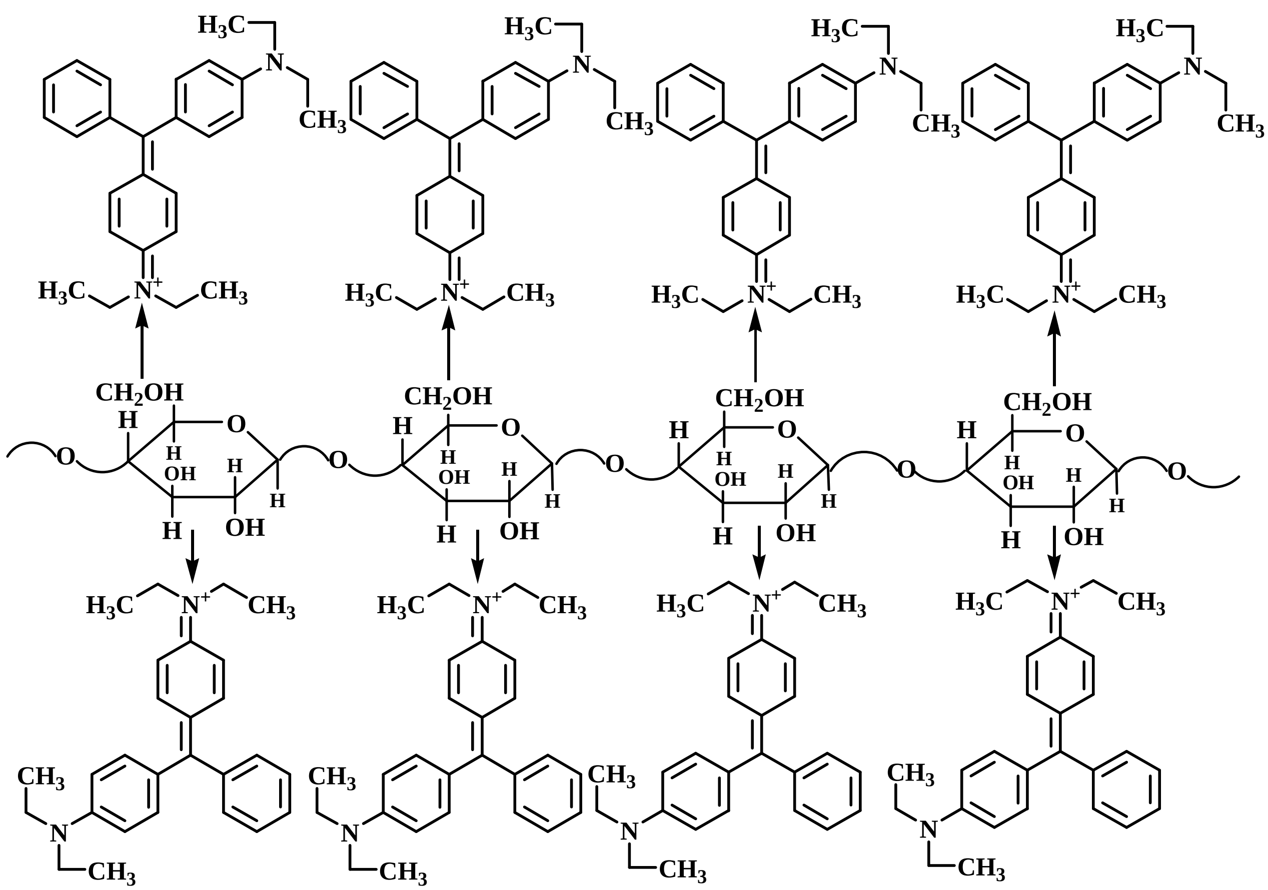
Adsorption Studies

1. Effect of contact time

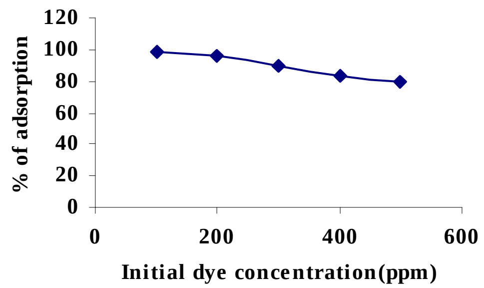
The effect of contact time on the adsorption of BG was carried out at room temperature for 100ppm solution. The adsorption increased with increase of time (Figure 1). The maximum adsorption 99% was observed at 6 hours for 100ppm solution. The adsorption percentage is very high due to the strong interaction of cationic BG on basic surface of sawdust (SCHEME 2 and 3) but the adsorption equilibrium was not estab-



SCHEME 2: Structure of sawdust (cellulose-basic surface)

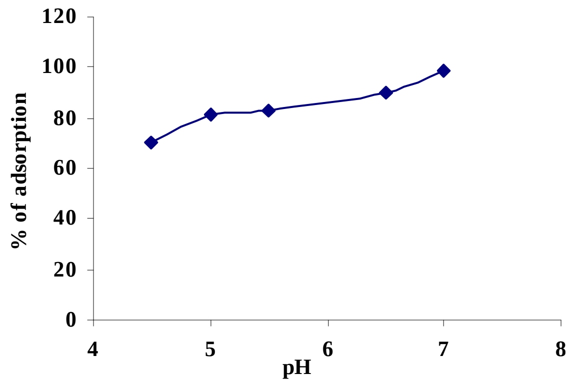


SCHEME 3 : Cationic brilliant green adsorbed on basic surface of sawdust (cellulose)



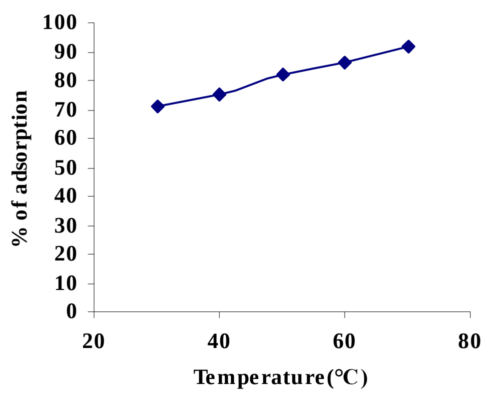
Temperature 30°C, dosage 200mg, particle size 0.6mm, Time 6h

Figure 2: Effect of initial dye concentration for the uptake of Brilliant green on sawdust



Temperature 30°C, Dosage 200mg, Particle size 0.6mm, Time 6h

Figure 3: Effect of pH on the adsorption of brilliant green on sawdust



Concentration 1000ppm, particle size 6mm, Time 6h, Dosage 200mg

Figure 4: Effect of temperature for uptake of brilliant green on sawdust

lished within 6 hours may be due to the multilayer adsorption of BG in sawdust.

2. Effect of concentration of dye

The effect of concentration of BG for maximum

TABLE 1: pH Changes during the BG adsorption on sawdust

Concentration(ppm)	Initial pH	Final pH	Removal(%)
100	4.70	6.62	95
200	4.00	6.30	90
300	3.95	6.25	88
400	3.90	6.00	85
500	3.80	5.61	83

uptake was studied between the concentration ranges 100 to 500ppm. The studies were carried out at room temperature. The adsorption capacity of the dye was found to be decreases from 99% with increasing the BG concentration (Figure 2). The percentage of uptake decreases with increase of BG concentration may be due to the saturation of active sites with BG molecule. Hence, adsorption decreases with increase of BG concentrations.

3. pH changes on the adsorption of Brilliant green on sawdust

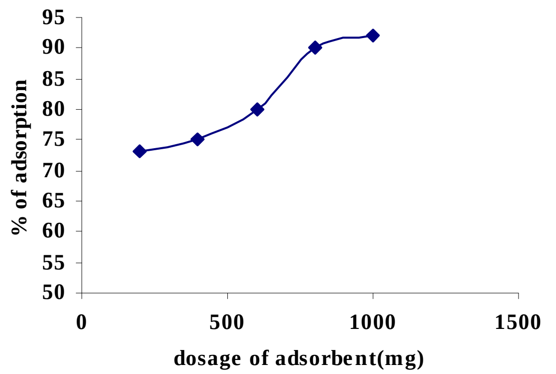
The initial and final pH of the BG solutions (100-500ppm**)** was measured before and after the adsorption experiments. The initial pH of BG solutions decreases from 4.70 to 3.80 with increase of dye concentration 100 to 500ppm (TABLE 1). After the adsorption process, the final pH of all solution were measured and observed that the pH increases nearer to water pH with increase of adsorption of BG on sawdust. This indicated that the water pH is not affected during the adsorption process.

4. Effect of pH

The pH effect on the adsorption of BG on sawdust were studied from 4.5 to 7 and observed that the adsorption increases from 70 to 99% (Figure 3). This indicate that the sawdust surface become more negative to attract the cationic BG molecule when increases the pH of the solution. Hence, adsorption increased with increase of pH of the dye solution. This is the evidence for the strong BG adsorption on basic surface of sawdust (SCHEME 3).

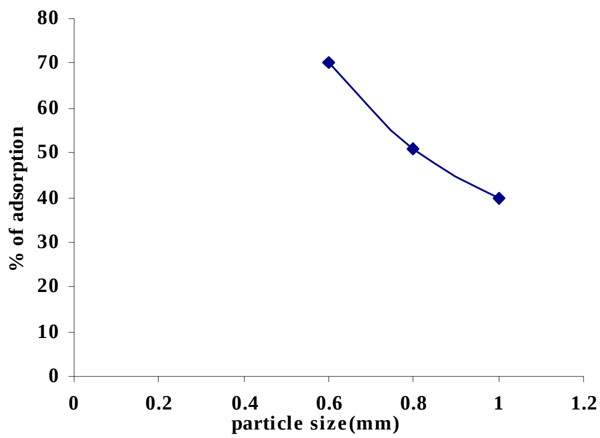
5. Effect of temperature

The effect of temperature for the removal of BG was studied for the concentration of BG solution 500ppm in the range of 30 to 70°C (Figure 4). The adsorption increased 71 to 92% when the temperature increases from 30 to 70°C.This indicate that the adsorption is



Concentration 1000ppm, particle size 0.6mm, Time 6h,Temperature 30°C

Figure 5: Effect of absorbent dose for uptake of brilliant green on sawdust



Temperature 30° C, concentration 1000 ppm, Time 6h, Dosage 200mg

Figure 6: Effect of particle size for the uptake of brilliant green on sawdust

endothermic and chemisorption.

6. Effect of dosage

The effect of adsorbents dosage (200-1000mg) for adsorption of BG was studied. The percentage adsorption of the dye was found to be increased with increase of adsorbent dosage (Figure 5), since the increasd dosage increases the surface area and active sites for more adsorption of BG on sawdust. The adsorption capacity of BG was 180mg/g.

7. Effect of particle size

The particle size of the sawdust was studied and observed that the adsorption decreases from 70-40% with increase of particle size 0.6 to 1.0mm. When the particle size increases, the surface area decreases and hence the adsorption decreases (Figure 6).

TABLE 2 : Comparison of adsorption capacity of BG on cellulose based adsorbents

Dyes	Adsorbent	Adsorption capacity (mg g^{-1})	References
Brilliant green	Rice husk ash	25	[13]
	Bagasse fly ash	133	[14]
	Neem leaf	167	[15]
	Sawdust	180	Present work

TABLE 3 : Desorption of BG from sawdust

Solvent	Volume of solvent(ml)	Adsorption (%)	Removal (%)
Water	50	99	5
Methanol	50	99	54
Ethanol	50	99	64

Time 1h, particle size 0.6mm, Temperature 30° C, Dosage 200mg

8. Adsorption on cellulose based materials

The BG adsorption on cellulose-based adsorbents is given in TABLE 2. The rice husk ash and bagasse fly ash are prepared from plant materials (cellulose). The adsorption capacity on both adsorbents are poor may be due to the destruction of basic groups present in cellulose during the ash preparation. Hence, cationic BG adsorption on both adsorbents is not much favourable. However, adsorption on sawdust and Neem leaf powder is favourable due to the strong interaction between the cationic BG and basic groups present in the cellulose materials (SCHEME 3). Hence, adsorption of cationic BG on raw cellulose materials like Neem leaf powder and sawdust are higher than rice husk ash and bagasse fly ash.

2. Desorption

The desorption of adsorbed dye molecule on sawdust was studied by using solvents like water, methanol and ethanol. The desorption tendency of BG in solvents are in the increasing order of water<methanol <ethanol. The dye-desorption is given in TABLE 3. The desorbed dye is characterized by spectrophotometer and confirmed (λ_{max} 630nm) that the dye nature is not affected. The percentage desorption of BG from sawdust is shown in the TABLE 3.

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