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RESEARCH ARTICLE

OPTIMIZATION OF SYNTHESIS OF BIOCHAR FOR THE REMOVAL OF CATIONIC DYE FROM AQUEOUS SOLUTION

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Abstract

Water Pollution continues to be a threat throughout the world, being an important source in the ecosystem it is necessary to reduce the contamination. The Effluents from textile industries are one of the major contributors for the water pollution. This work investigates the adsorption efficiency of bio char produced from Curry tree stem for the removal of Safranin-O dye from waste water. Batch adsorption experiment was done to study the effect of operational parameters such as adsorbent dosage, time, temperature and initial dye concentration. Thus our results provide novel perception into the potential of biochar to remove Safranin-O from textile effluents.

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Introduction:-

The Major environmental threat is the water pollution due to dye effluents (Sneha et al., 2013). The primary pollutant to be found in wastewater is colour which can be detected when it is less than 1ppm (Couto, 2009). Dyes are primarily used in numerous industries such as textile, paper printing, food, pharmaceutical, leather and cosmetics producing a large quantity of coloured waste water. Among all the dyes used in the production of consumer products, textile industries are placed in the first position in utilizing dyes for coloration of fiber (Reisch, 1996).

The textile industry is one of the most water-intensive sectors in the world, with processes such as bleaching, dyeing, and printing globally consuming over 80 billion cubic metres of water per year. Environmental pollution especially due to dyes is the most crucial problem in India. The major pollutants contaminating the environment are Industrial effluents, sewage and farm wastes. Mostly the Industrial effluents discharge Toxic materials into rivers without sufficient treatment (Lakherwal, 2014). Dyes released into the waste water from various industrial outlets have toxic and carcinogenic effects on microbial population and aquatic life. Therefore they are required to be removed before discharging into the water bodies. Dyes are usually light stable and are non biodegradable. They are impervious to aerobic digestion and signify one of the strenuous groups to be removed from industrial wastewater (Ardejaniet al., 2007)

Due to environmental and health impact of dyes it is essential to remove the toxic pollutants before disposal. Different separation techniques have been used in the removal of dyes such as physical, chemical and biological methods. Adsorption is one of the commonly used techniques used in treating effluent water. It is defined as a surface phenomenon which deals on adsorbing the concentration of materials on the high surface area of the adsorbing body (Yagubet al., 2014). The use of agricultural materials in adsorbing toxic materials from effluent is known as biosorption and is superior in treating effluents in comparison to other treatment methods due to its low

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cost, and easy availability (Ajaelu et al., 2017). Activated carbon is a form of carbon derived from charcoal and is processed to have low volume pores and large surface area. Thus it is highly applicable in adsorbing the pollutants from waste water (Soo et al., 2013).

Safranin-O or Basic red 2 is a basic dye under the triphenyl methane dyes. This is an azonium compounds of symmetrical 3,7-Diamino-2,8-dimethyl-5-phenylphenazin-5-ium chloride as shown in Fig .1. Safranin-O dye is widely used in textile industries and creates threat when it is disposed into water bodies (Ajaelu et al., 2017)

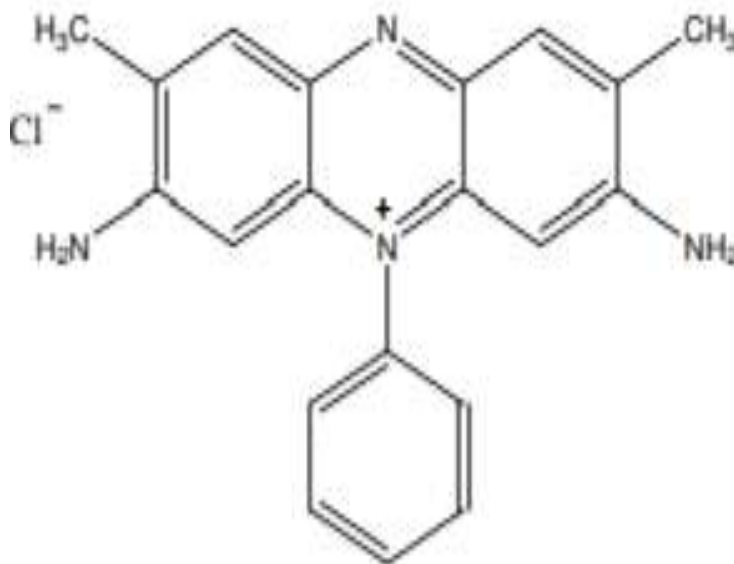


Fig .1:-Chemical structure of Safranin-O

Materials and Methods:-

Materials:-

Curry Tree Carbon(CTC) was collected from a local vegetable market as a Bio waste. Safranin-O was obtained from Kem light laboratories private limited, Mumbai, India. Sulphuric acid was purchased from M.V Krishnaaram laboratories chemicals company Perungudi , Chennai , India.

Synthesis of Ctc:

The barks of curry tree plant were collected as a vegetable waste from local market and are cut into small pieces after removing the rinds. It was dried at 110°C for 1 hour in a hot air oven. The dried pieces (50g) was treated with concentrated sulphuric acid (1: 1 w/v).The barks were taken in small quantities and mixed with concentrated sulphuric acid by continuous stirring .This caused charring of the material and was followed by evolution of heat and fumes. The mixture was cooled to room temperature and washed with distilled water in order to remove the free acid completely and was filtered and dried at 110°C.This was further heated at 170 °C for 90 min in a muffle furnace to complete carbonization and activation. The material was washed with distilled water until the slurry reached a constant pH and dried at 110°C for one hour in hot air oven.The dried carbon was finely ground and sieved. The resulting carbon from Curry leaf tree was abbreviated as Curry tree carbon (CTC) (Prabha et al., 2016).

Preparation of safranin-o-o dye solution:

Stock solution was prepared accurately by dissolving 0.1g of Safranin-O-O dye in one litre of distilled water. Later, desired amounts of stock were taken and diluted using distilled water.

Batch Adsorption Study:

In this experiment, batch adsorption technique was used. In order to study the effects of various important parameters such as adsorbent dosage, contact time and temperature and dye concentration, it was conducted at different conditions viz adsorbent dosage (50-300 mg L⁻¹), time (20-160 min), temperature (35°C -55°C) and dye concentration (10mg/L – 80mg/L).The sample was filtered after analysis using whatmanNo.42 filter paper. The dye

concentration was estimated spectrophotometrically at the wavelength 580nm using UV spectrophotometer. The amount of dye uptake at equilibrium is calculated using the equation.

$$q_e = \frac{(C_0 - C_e) V}{w}$$

Where,

q_e is the dye uptake taken by the adsorbent (mg/g)

C_0 is the initial crystal violet dye concentration (mg/l)

C_e is the dye concentration after adsorption process (mg/l)

W is the mass of the adsorbent taken (g)

V is the volume of the dye solution taken (l)

The percentage removal of the dye is calculated using the equation

$$\% \text{ Removal} = \left(\frac{C_0 - C_e}{C_0} \right) 100$$

Where,

$C_0 - C_e$ is the difference in the dye concentration before and after adsorption.

Results and Discussion:-

Effect of adsorbent dosage:

The effect of adsorbent dosage on the removal of Safranin-O dye is shown in Fig 1. It was carried out at different dosages of biochar ranging from 50 mg L⁻¹ to 300 mg L⁻¹. The other parameters such as pH was kept at neutral, at constant time (60 min) and initial dye concentration was 30 mg L⁻¹.

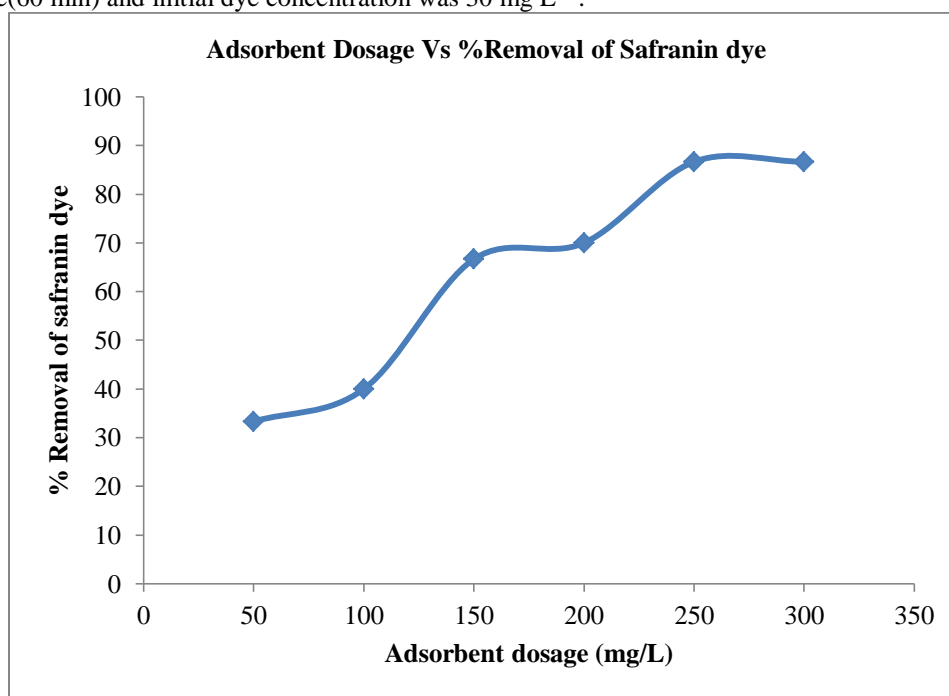


Fig .1:-Effect of varying adsorbent dosage for the removal of Safranin-O dye

It is observed that the percentage dye removal increased from 33.33% to 86.66% as the adsorbent dosage increases. This is due to an increase in surface area and more site for adsorption of dye to occur on the adsorbent (Suresh, S et al,2011)

Effect of Contact Time:

The equilibrium time required for the adsorption of Safranin-O on CTC with 250 mg L⁻¹ of the biosorbent at different time intervals was studied. Fig.2. Showed that the adsorption capacity sharply increased with increase in time and attained equilibrium at 120 min. The adsorption attains an equilibrium at 120 min which infers that the adsorbent tends to saturate with the dye. The rate of adsorbent is higher in the beginning due to large surface area of

the bio char and after the CTC gets exhausted i.e. at equilibrium, the rate of uptake is restrained by the rate of mass transfer of the dye from exterior to interior surface of adsorbent(Vermaet al., 2006)

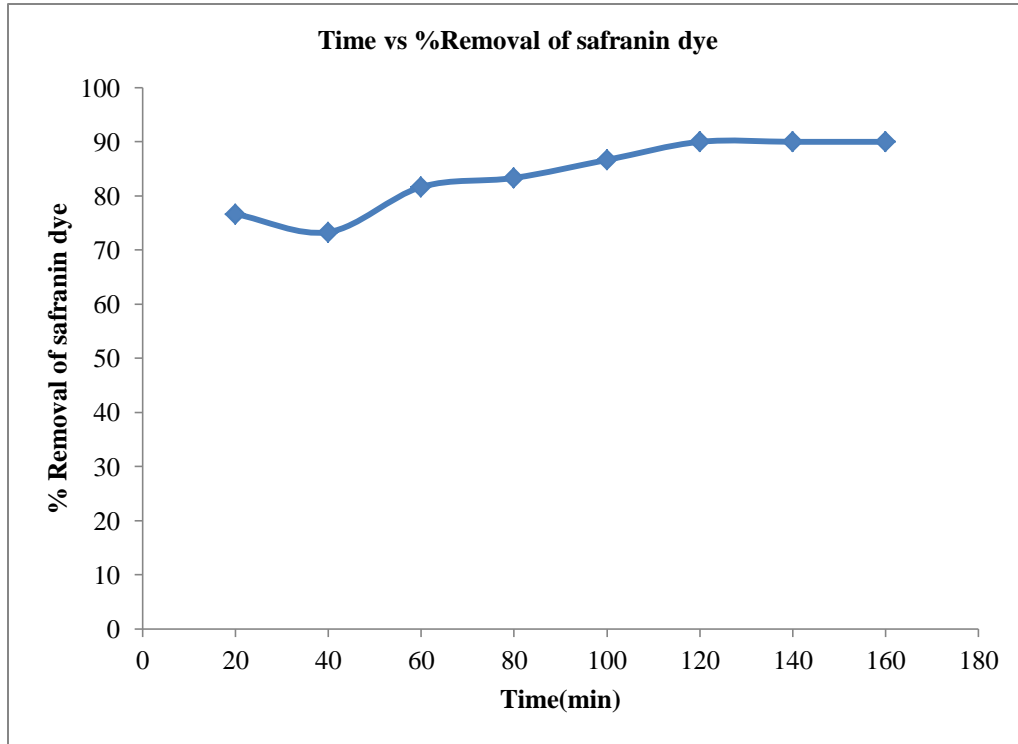


Fig.2:-Effect of varying contact time for the removal of Safranin-O dye

Effect Of Temperature:

The adsorption of Safranin-O from dye solution using CTC is carried out in the temperature range from 35°C - 55° C. It is observed that low temperature favoured the adsorption process as the removal efficiency is maximum at 96.66% as shown in Fig.3.

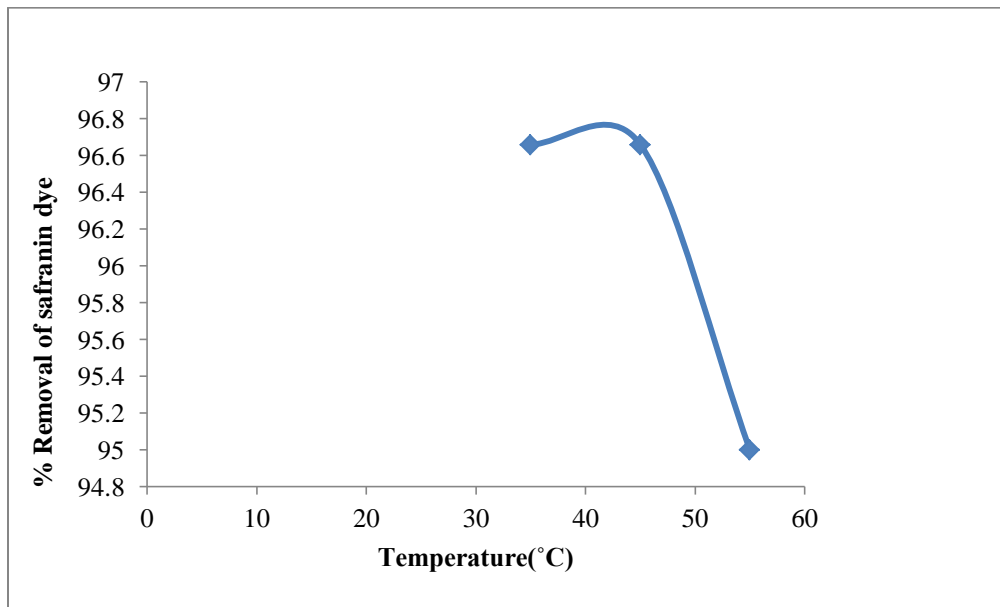


Fig.3:-Effect of temperature for the removal of Safranin-O dye

Effect of Initial Dye Concentration:-

The effect of dye concentration depends on the instant relation between the Safranin-O concentration and the accessible binding sites on the surface of the adsorbent (Umoren et al. 2013). A sample of 250 mg L⁻¹ of CTC was added to varying concentration of Safranin-O dye solution ranging from 10 mg L⁻¹ - 80 mg L⁻¹. The mixture was allowed to react at 35° C for 120 min. The effect of the initial Safranin-O concentration, and its % removal, is shown in Fig 4. The amount of Safranin-O adsorbed increased with the increase in the dye concentration and it is found to be optimum at 30 mg L⁻¹. On further increase in dye concentration the removal efficiency decreased. This is due to the decrease in availability of active sites on adsorbent to adsorb the Safranin-O dye. Hence it is required to increase the adsorbent dosage as the concentration of the dye increases.

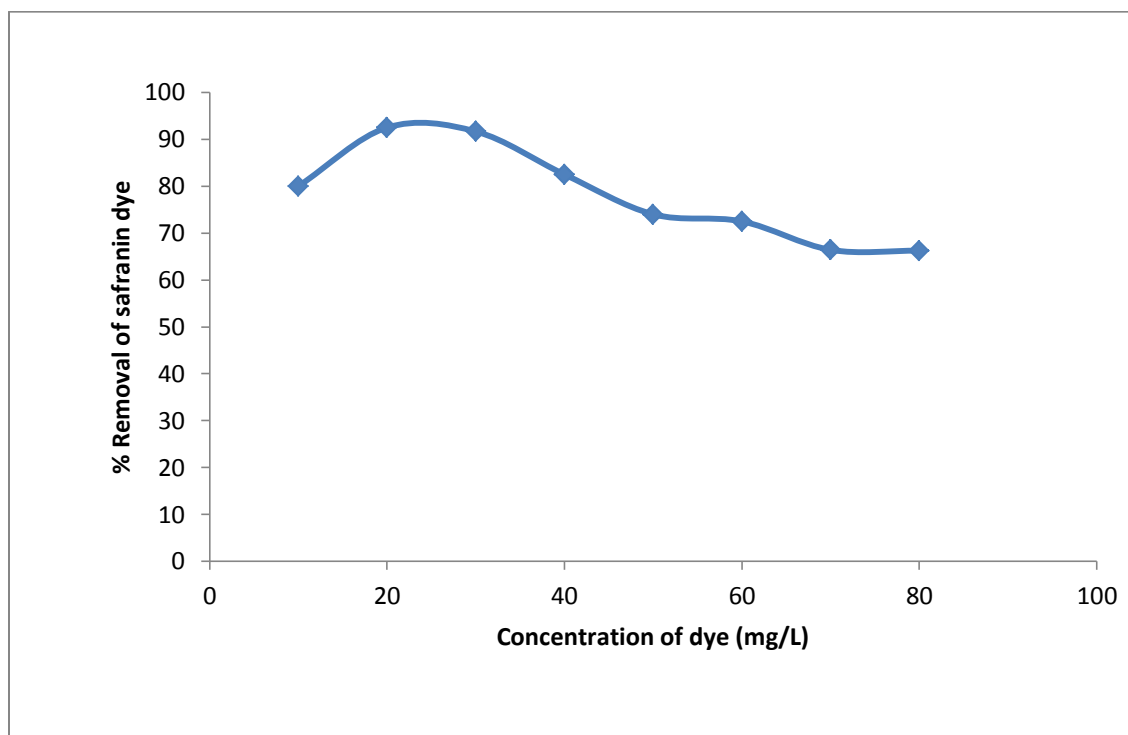


Fig .4:-Effect of initial dye concentration.

Conclusion:-

The adsorption capacity of Curry tree carbon on the removal of safranin was examined. Batch adsorption experiment was carried out as a function of variables such as adsorbent dosage, time, temperature and dye concentration and subsequently the optimum conditions were determined. The obtained results inferred that the optimum adsorbent dose (250 mg/L), time (120 min), temperature (35°C) and initial dye concentration (30 mg/L) had a pronounced effect on the removal of safranin from aqueous solution. Detailed study should be carried out on adsorption isotherm models and adsorption kinetics to evaluate the mechanism of adsorption.

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