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INDUSTRIAL WASTE WATER TREATMENT USING NATURAL ADSORBENTS

Bhavesh Kamble[1], Prathamesh Bhusari[2], Vatsal Shah[3], Vijay Mane[4], Mahesh Suryawanshi[5]

[1, 2,3,4,5]*Department of Chemical Engineering, Bharati Vidyapeeth College of Engineering*

Abstract - *The textile dye industry is the largest consumer of dye stuffs. During the coloring process a large amount of synthetic dye does not bind and is lost to the waste system. These dyes are difficult to remove in conventional wastewater treatment processes and can be transported easily through sewers and rivers especially because they are designed to have high water solubility. The effluent streams from these textile industries leads to serious water pollution problems. For separation of dyes from these effluent streams, adsorption technique is used in this study. Adsorption is a surface phenomenon in which the liquid phase solutes in gas or liquid phase are adsorbed on the surface of the adsorbents. Adsorption using natural adsorbents is more feasible and economical as the natural adsorbents are available in bulk and majorities are usually waste products. Adsorption can bedone using two methods, primarily on lab scale, using lab apparatus such as beaker with constant stirring where the adsorbent and dye solutions are intimated for a specific period; secondly it can also be done in a packed bed in which packing is made up of the adsorbents. Adsorbent used in this study is Banana peels. Different parameters were altered during the experimentation such as adsorbent dosage, concentration of adsorbent solution, time of contact and keeping temperature constant. Adsorption is a low-cost waste water treatment process and is comparatively economical than advanced oxidation processes and filtration processes. The optimum adsorbent dosage was 4-5 grams in 100ml dye sample for time 60mins.Adsorption using banana peels has achieved up to 92% removal of methyl red as per the experimentation at 50ppm dye concentration. The equilibrium adsorption behavior was carried out by plotting Freundlich's adsorption isotherm. Adsorption of Methyl Red dye on the banana peels is quite low but comparable to activated carbon.*

Keywords – *Methyl Red, Toxicity, Wastewater Treatment, Adsorption, Banana peels, Freundlich's Isotherm.*

I. INTRODUCTION

Textile industries are one of the most important industries in India. The basic work of textile industries is to provide good quality of fibre to the society. The vital operations that are carried out in textile industries are spinning, knitting, warping, texturing, slushing, weaving, desizing, bleaching, dyeing and finishing operations. Out of all these operations bleaching, dyeing and finishing operations include chemical treatment of the fabric, rest all of the processes are physical and mechanical processes. During the chemical treatment such as in dyeing operation synthetic dyes are used in order to impart the colour to the fabric. These dyes are high molecular weight organic and aromatic compounds containing Azo bond (-N=N-). The waste water from the effluent stream of the industry contains harmful concentrations of these dyes. The presence of these dyes in traces can cause acute human health hazards and if present in tremendous amount lads to chronic hazards. These waste water detoriates the water bodies by reducing the DO level of the water, affecting COD, BOD and TOC of water, increases turbidity and thereby affects the water ecosystem. Many treatment techniques are used in order to degrade the dye from waste water. Some of the techniques are oxidation, ozonation, photocatalysis, membrane separation, evapouration etc. All these processes are highly expensive as it deals with harmful chemicals, heating systems, high pressure systems and membrane modules. In this study Adsorption process is chosen as the treatment technique for waste water. Adsorption process usually involves an adsorbent on which the dye molecules adhere superficially. Adsorbent used is activated carbon in almost all the operations. This study involves adsorption of textile dyes with natural adsorbents. Natural adsorbents are used as they are found in day to day waste, abundance in nature, non-toxic and biodegradability. In this study adsorbent used was banana peels powder. Dye used in the study is Methyl Red due to its large usage in industry, harmful effects, toxicity and carcinogenicity. Different parameters such as adsorbent dosage, dye concentration and time were altered in order to check their effect on the degradation. Different authors have studied different dyes and adsorbents. The study of different dyes and biosorbent done by Quarratulane Bari and NagendraBharadwaj[1] suggested that Carica papaya bioadsorbent gave 79% decolorization with methyl red dye, 83% with methyl orange dye, 67% with crystal violet and 41% with malachite green, similar study when done by activated carbon as adsorbent showed 72% decolorization with methyl red, 83% for methyl orange, 71% for crystal violet and 49% for malachite green.Hence it concludes that the natural biosorbents have a capacity and potential to adsorb the dye from waste water comparable to activated carbon.

II. MATERIALS AND METHODS

Preparation of adsorbent

The peels were collected from the fruit vendors and juice centers. Around 2-3kg peels were collected. The peels were kept in the sunlight for drying purpose for a week to remove the bound moisture. The dried peels were collected until they were brownish-black. These peels were packed in an air tight bag. Further they were washed to remove the dust particles and then kept in the hot air drier at 105^{o}C for 3-4 hours for further removal of the moisture. The peels were removed when they were black and crisp. They were then packed in the air tight bags. The peels were grounded to powder in a daily house hold mixes used in kitchen. The powered peels were collected and then sieved in a sieve shaker. The particles of different sizes are collected out of which particles of 250 microns were selected for the experimentation. The 250 micron particles were kept separately in an air tight bag in order to cease the further contact with moisture and air. This powder was used for the further adsorption process.

Preparation of standard dye solution

The dye stock solution for methyl red was prepared using distilled water. The solution was prepared to have a concentration of 100 mg/L, 75 mg/L and 50 mg/L. For 100 mg/L, 0.1 gram of dye powder was dissolved in 1000 ml of distilled water. For 75 mg/L, 0.075 gram of dye powder was dissolved in 1000 ml of distilled water. For 50 mg/L, 500 ml of 100mg/L of solution was diluted with 500ml of distilled water, also 0.05 grams dye solution with 1000ml water results to 50 mg/L solution.

Batch adsorption study

The stock solution prepared was taken in 5 stoppered BOD bottles each containing 100 ml of solution. Adsorbent of size 250 micron was then taken with respect to requirement, i.e., 1gm, 2gm, 3gm, 4gm, 5gm and added to BOD bottles containing dye solution. The bottles were then subjected to vigorous shaking in a vibrating screen. After a time interval of 20 mins, 40 mins and 60 mins the solution from BOD bottles was pipetted out required enough for analysis. The collected sample was then put in centrifuge to separate the adsorbent powder from the solution.

The separated solution was then analyzed in Colorimeter. The amount of dye adsorbed on adsorbent was calculated by mathematical expression,

$$q_e = \frac{(C_o - C_e) * V}{W}$$

Where, q_e is milligrams of dye adsorbed per gram of adsorbent.

C_o is initial concentration of dye.

C_e is equilibrium concentration of dye at time t.

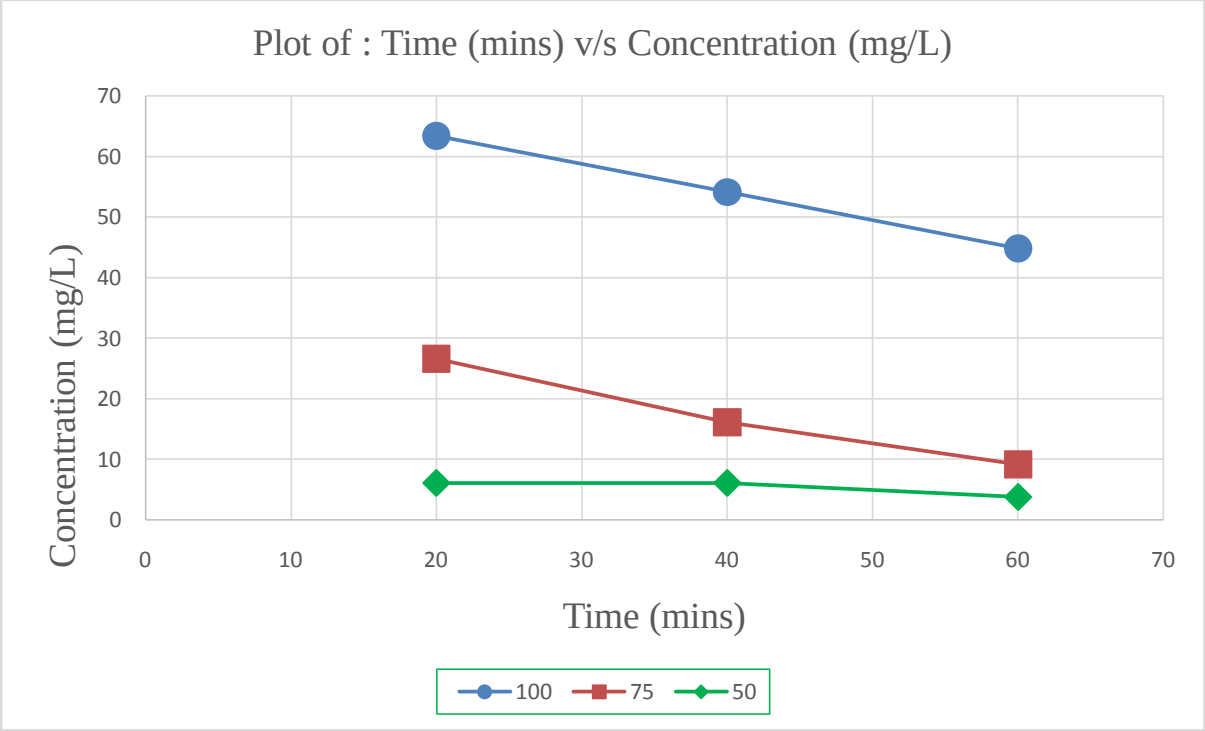
V is volume of solution taken for study.

W is grams of adsorbent added.

III. RESULTS AND DISCUSSIONS

Effect of adsorbent dosage

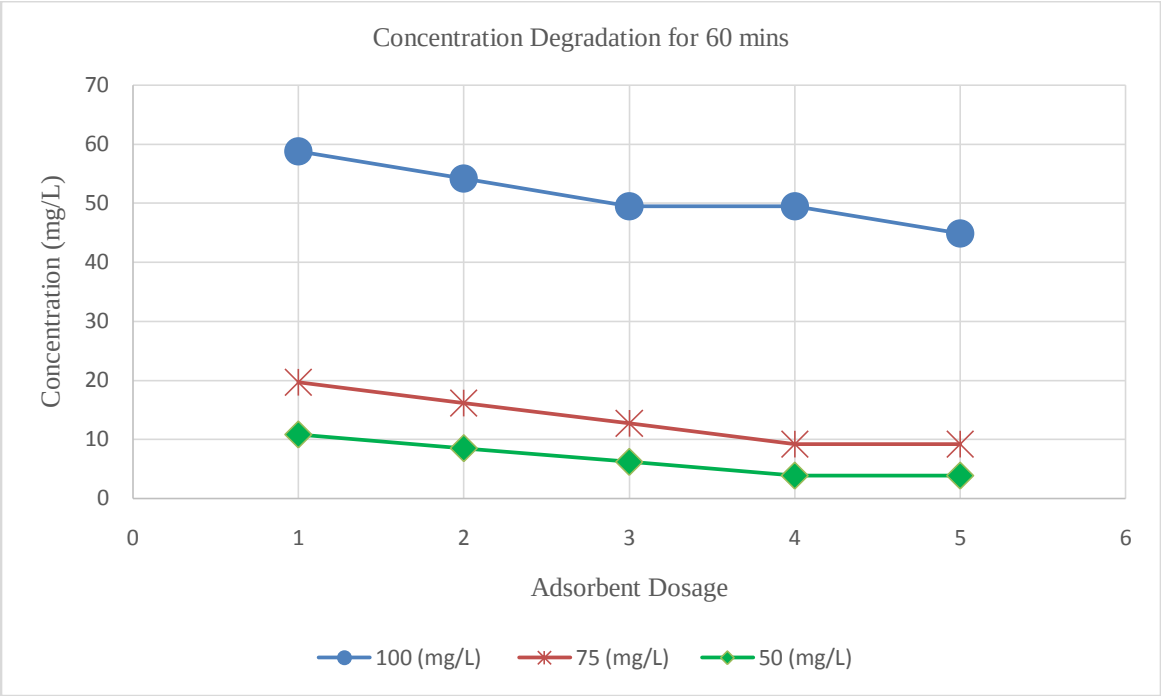
The adsorption capacity was increased with the increment of adsorbent dosage. The dye removal gradually increased when the adsorbent dosages were increased from 3gm to 5gm for 100ml solution. This result indicated that more surface area was made due to increased mass of adsorbent. Therefore, total number of sites increases. In addition the figure shows that, above 3gm of dosage the removal percentage is increased. So, 4gm to 5gm of adsorbent indicate the optimum amount.



"Figure 1. Effect of banana peels adsorbent on different concentrations of dye and time for 5g dosage of adsorbent."

Effect of contact time

In each adsorption experiment, 100 ml of dye solution of known concentration was added to 1gm, 2gm, 3gm, 4gm and 5gm of adsorbents in 300 ml round BOD bottles at room temperature and the mixture was then kept on a vibrating screen for shaking. The samples were taken at different intervals of 20min, 40min and 60min. Following figure shows that, there was an increase in removal efficiency with increase in contact time between adsorbate and adsorbent. It can be observed that more time becomes available for the dye to make an attraction with banana peels. The graph shows that, initial removal occurs rapidly as soon as the dye and peels in contact but after that when some of the easily available active sites engaged, dye needs time to find out more active sites for building. So, removal percentage is increased steadily over the period of experiment. It is concluded that dye and peels should be in contact for 60 minutes in order to get maximum removal percentage.



"Figure 2. Effect of banana peels adsorbent at different time 60 mins for different dosage"

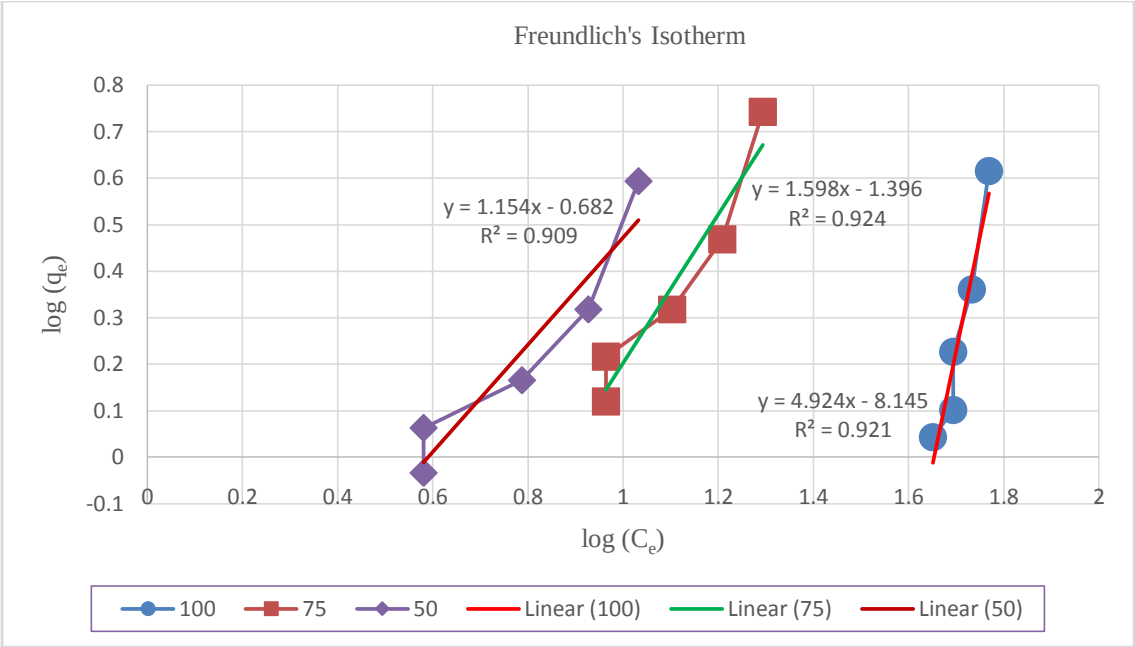
Adsorption Isotherm

Isotherms are plotted in order to determine the adsorption intensity and capacity of the adsorbent. Two isotherms are considered in this study. Freundlich's Isotherm and Langmuir's Isotherm. Freundlich's isotherm assumes the heterogeneous adsorption surface and non-uniform distribution of heat of adsorption. Mathematically it is given as,

$$\log(q_e) = \log K + \frac{1}{n} * logC_e$$

Where, q_e is milligrams of dye adsorbed per gram of sample.
C_e is equilibrium concentration of dye at time t.
K is adsorption capacity.
n is adsorption intensity.

Plot graph of log $q_e$vs log C_e ; we get slope as 1/n and intercept as log K.



"Figure 3. Freundlich's Isotherm for time 60 minutes at different concentrations"

"Table 1. K and n values for Freundlich's isotherm for different concentrations at 60 mins"

Concentration (mg/L)	K	n	R^2
50	0.505	0.866	0.9095
75	0.2473	0.6255	0.9246
100	0.203	0.00029	0.9291

IV. CONCLUSION

From this study, it may be concluded that the removal of Methyl red dye from textile wastewater by adsorption on banana peels has been found to be useful for controlling water pollution due to dyes. From this experiment it is clear that, the adsorption of dyes onto banana peels is influenced by dosage of adsorbents and contact time. In the review the efficiency of banana peels as an adsorbent has been studied. For higher removal of dyes from textile effluents adsorbent dose of more than 3gm was favorable. The uptake of the dye increased with increasing contact time and the optimum contact time was obtained at 1 hours. The removal of dye was 92% for concentration of 50ppm, adsorbent dosage of 5g and contact time of 60 mins. Also, the adsorption of dyes onto banana peels follows the Freundlich's isotherm model. Even though the removal efficiency of banana peels is not much higher than other bio-adsorbents but it is comparable to activated carbon. With this cheap and environment friendly adsorbent considerable dye removal can be achieved. So it can be substituting other expensive bio-adsorbents. With the experimental data obtained in this study, it is possible to design and optimize an economical treatment process for the dye removal from industrial effluents.

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