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EXPERIMENTAL INVESTIGATION ON REMOVAL OF COLOUR IN WASTEWATER USING BIO-ADSORBENTS

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ABSTRACT

Textile Industries, Dye stuff units and pulp units are considered to be basic contributors to colour in receiving water bodies. These industries have always had a processing technique for colour removal in effluent streams. The removal of dyes present in industrial effluent has received great attention in the last few years. It is due to the increase in awareness and rigidity of the environmental rules. Adsorption is one of the techniques that has been used with success for the effective removal of dyes. However, the efficiency of the adsorption process depends on the choice of a proper adsorbent. Because of the high cost of some conventional adsorbents, research has been directed to the use of alternative adsorbents. The present study involves an investigation of low-cost adsorbents like orange peel, neem leaves and banana peel with their colour removal characteristics and compared their performance. The proposed dyestuff for the ongoing study is Methylene Blue. The influence of various factors such as the Effect of time, Effect of Adsorbent dosage and Effect of pH has been studied. Based on the results from the batch studies a simple adsorption column for lab-scale has been studied. From the observations and discussions, it was found that the colour-removing capacity of the Orange peel is found to be very effective. Adsorbents like Neem leaves and Banana peel were also found to be effective.

Keywords: Adsorbent, Colour removal, Neem leaves, Banana peel, Orange peel

INTRODUCTION

Water is essential for human health and for the health of the nation's economy. The growing population and rising standard of living of people are pushing up the demand for quality industrial products at a phenomenal pace. Thus the industrial need for water is increasing day by day. As one of the major users of this precious resource, the industry has an important responsibility to practice water audit and water conservation.

Industries can realize many benefits from the practice of water audit and Water Conservation. By reducing the use of water, industries can not only affect shaving but also protect the environment. Industrial effluents constitute a major source of polluted water and contain different kinds of toxic pollutants. Treatment of industrial wastewater may be necessary to lower the concentration of toxic pollutants in wastewater to the level of permissible limits. With the quality of water becoming poor, availability of fresh water being scarce and statutory environmental regulations becoming more stringent, optimization in the use of water demands closer monitoring by the industrial sector.

Dyes are chemicals which on binding with the material will give colour to the material. Dyes are ionic, aromatic organic compounds with structures including aryl rings which have delocalized electron systems. The colour of a dye is provided by the presence of a chromophore group. A chromophore is a radical configuration consisting of conjugated double bonds containing delocalized electrons. The Chromogen, which is the aromatic structure normally containing benzene, naphthalene or anthracene rings, is part of a chromogen-chromophore structure along with an autochrome. The presence of ionizing groups known as auxochromes results in a much stronger alteration of the maximum absorption of the compound and provides a binding affinity. Coloured dye wastewater arises as a direct result of the production of the dye and also as a consequence of its use in textile and other industries. There are more than 100,000 commercially available dyes with over $7x10^5$ of dyes produced annually. It is estimated that 2 % of dyes produced annually are discharged in effluent from manufacturing operations whilst 10 % was discharged from textile and associated industries. Adsorption techniques for wastewater treatment have become more popular in recent years owing to their efficiency in the removal of pollutants too stable for biological methods. Adsorption can produce high-quality water while also being an economically feasible process. Decolourisation is a result of two mechanisms – adsorption and ion exchange and is influenced by many factors including dye/sorbent interaction, sorbent surface area, particle size, temperature, pH and contact time. Physical adsorption occurs when weak inter-particle bonds exist between the adsorbate and adsorbent. Examples of such bonds are van der Waals, Hydrogen and dipole-dipole. In the majority of cases, Physical adsorption is easily reversible. Chemical adsorption occurs when strong interparticle bonds are present between the adsorbate and adsorbent due to an exchange of electrons. Most adsorbents are highly porous materials. As the pores are generally very small, the internal surface area is orders of magnitude greater than the external area. The objectives of the study are as follows:

- To evaluate the feasibility of using locally available low-cost adsorbents from water waters and decolourization of textile dye effluent.
- To compare the performance of the low-cost adsorbents
- To examine the impact of pH and contact time on the adsorptive capacity of these adsorbents

MATERIALS AND METHODS

Adsorbents like Orange Peel, Neem leaves and Banana peel is collected from the local areas of Thanjavur District. The peels and leaves are collected and dried in the sunlight for the removal of moisture content present in it. After the drying process the peels were cut into small pieces and grinded well to a very fine size, similarly the neem leaves were also powdered.

Preparation of the Adsorbent

The adsorbent preparation plays a vital role in the adsorption process. Hence the preparation of adsorbent is very important. The following categories are adopted in this analysis:

- Nominal Treatment (N)
- Physical Treatment (P)
- Chemical Treatment (C)
- Thermal Treatment (T)
- Physical-Chemical Treatment (PC)
- Chemical-Thermal Treatment (CT)
- Physical-Thermal Treatment (PT)

Equipments and materials used for Experimental Investigation

- UV-Visible Spectrophotometer used for measuring absorbance
- Digital Balance used for weighting the adsorbents
- Distilled water is used for mixing purposes
- 20 ml test tubes are used for Batch studies

Details of Adsorbate

The proposed dye stuff used for our study is Methylene Blue. The details of Methylene blue are given below:

- Chemical formula:- $[(CH_3)_2N]C_{12}H_6NS(OH)$
- Molecular Weight: 301.49
- Colour: Blue
- Type of Dye: Basic
- General Category: Triphenyly Methane Dyes (Heterocyclic)
- I_{max}: 665
- pH: 6.50 (Measured at an initial concentration of 1000 ppm)

Experimental Procedure

- Collection of Adsorbent and Adsorbate
- Calibration of Methylene Blue
- Effect of time using various adsorbents
- Effect of adsorbent dosage using various adsorbents
- Identification of an Ideal adsorbent
- Effect of pH using Ideal adsorbent
- Column Studies

RESULT AND DISCUSSIONS

The synthetic dye sample is calibrated in order to find out various optical densities at various concentrations. The calibrated results are very effective to identify the respective colour removal capacities of various adsorbents as shown in Figure 1

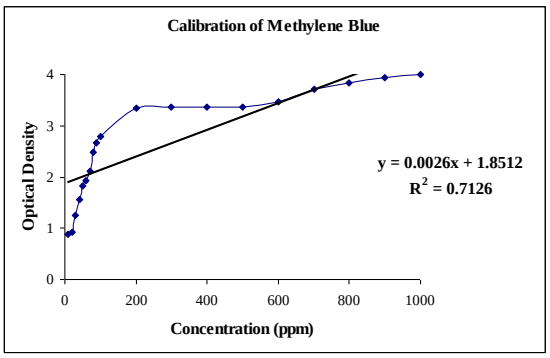

Figure: 1 Graph showing the Calibration of Methylene Blue

Effect of Time using Various Adsorbents

A set of 250ml reagent bottles was used for the present study. 20ml of the stock solution of 1000ppm was taken and weighed amount (0.1gm) of adsorbent were fed into the bottles and kept for agitation at 150 RPM using bottle shakers for a period of various time periods with a regular interval of 10 minutes each. At the end of each 10 minutes the agitated sample is taken from the shaker and tested for its optical density using the UV-Visible Spectrophometer. The corresponding Optical Density is interpolated with the initial calibration values in order to find out color removal efficiency of the adsorbent. Figure 2 indicates that the removal efficiency for various adsorbents

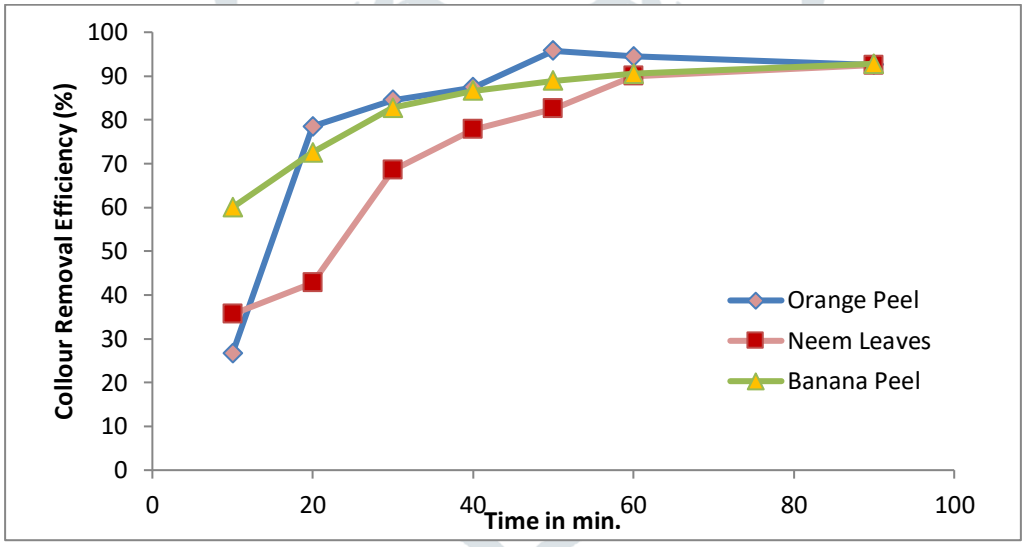

Figure: 2 Graph showing the Comparative results of various adsorbents on to Effect of Time

From the Comparative results is it clearly known to us, the effect of time plays a very important role in adsorption process of colour removal? All the adsorbents are quite effective, but Orange peel is found to very effective next to activated Carbon. The colour removal efficiencies of the adsorbents have a break through at 60 minutes, in which there is no further colour removal takes place. Orange Peel is found to be very effective having a colour removing efficiency of 96%.

Effect of Adsorbent Dosage using Various Adsorbents

A set of 250ml reagent bottles was used for the present study. 20ml of the stock solution of 1000 ppm was taken and weighed amount (0.2, 0.4, 0.6, 0.8, 1.00 gm) of adsorbent were fed into the bottles and kept for agitation at 150 RPM using bottle shakers for a period of various time periods with a regular interval of 45

minutes each. At the end time interval the agitated sample is taken from the shaker and tested for its optical density using the UV-Visible Spectrophometer. The corresponding Optical Density is interpolated with the initial calibration values in order to find out color removal efficiency of the adsorbent.

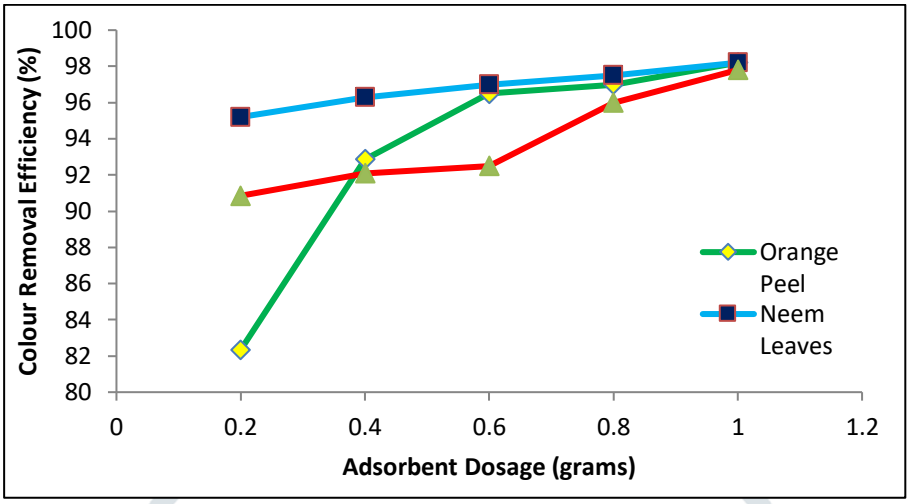

Figure: 3 Graph showing the Comparative results of various Adsorbents on to Effect of Adsorbent Dosage

From the Comparative results it is clearly known to us that the Effect of Adsorbent Dosage is also plays a very vital role in adsorption process for colour removal. Among the three adsorbents it was, Orange peel found to be very effective next to Activated Carbon. So, from the two parameters such as Effect of Time and Effect of Adsorbent dosage we confirmed that Orange peel is found to be an excellent adsorbent compared to Neem leaves and Banana Peel. The maximum colour removal efficiencies of Orange peel, Neem leaves and Banana Peel at dosage of 1.00gram for time duration of 45 minutes is found to be 98.76, 97.77 and 97.93 respectively.

Effect of pH on to Orange Peel for Colour Removal

To confirm the efficiency of the Orange Peel, series of experiments were conducted at various pH. The initial pH of the stock solution prepared was 6.50 at 1000 ppm. The pH conditions are found to be effective under acid and alkaline conditions. The stock solution was converted to various pH. For pH 2 and 4.00 is considered for the acidic conditions and 8 and 10 is considered for alkaline conditions. For converting acidic conditions HCL is added and NaOH of 0.1N is added for transforming alkaline conditions.

The reagents bottles were taken and stock solution of 20ml is poured into the bottle and equal adsorbent dosage of 0.1gram was fed into the bottle and bottle is kept for continuous shaking. Reading was taken at regular interval using UV- Visible Spectrophotometer. First the effect of pH under acidic conditions was noted. But the effect of pH under acidic condition imparts a new colour to the solution. The colour of methylene blue is converts into greenish yellow which the respective optical density is found to be more than 4.00 (i.e., more that value of the stock solution at 1000 ppm) this is found to be very remarkable, because of the acidic elements already present in the Orange peel imparts a new colour to the stock solution. Then the sample is test at pH 4. A new colour was delivered but gives a value slightly more than 4.00. So, it was concluded that the effect of

Colour removal under acidic conditions using orange peel as an adsorbent is found to be very ineffective. Then it was tried with alkaline pH in order to find out the efficiency. The same solution is converted into alkaline condition by treating it NaOH of normality 0.1N. The same testing procedure was followed for the efficiency of colour removal using orange peel. It showed some good results; the results obtained were tabulated below with their respective graphs. The sample was checked for effect of time at a regular interval of 10 minutes each starting from 10 minutes to 60 minutes. The pH considered for alkaline studies were 8 and 10.

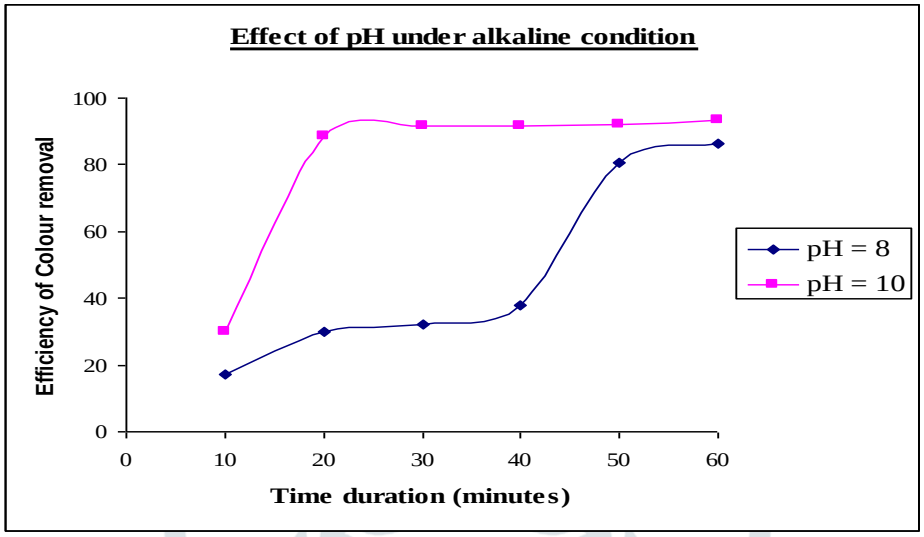

Figure: 4 Graph showing the Comparative results for the Effect of pH under alkaline conditions

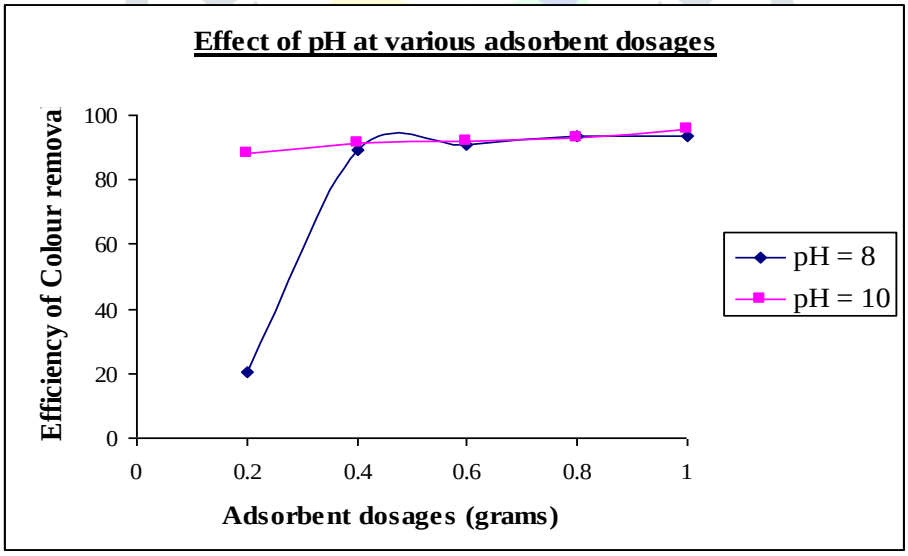

Figure: 5 Graph showing the Comparative results for the Effect of pH under alkaline conditions at various adsorbent dosages

Column Studies using Orange peel

Orange peel found as an effective adsorbent in colour removal in batch studies, so some column experiments were conducted using 50ml burette. The columns study using burette was found to be very economical one; the flow to this system is applied by means of gravity only. No external driven force is applied to the system. 7 burettes are taken in which 10ml is filled with the adsorbent and remaining 40ml is filled with

adsorbate, where fine particles are placed below the adsorbent for fine filtration. The filtration materials should be a non-adsorbent; here in our case we use fine pebbles. The fine pebbles were clearly washed to several times in order to removal the dust particles and foreign particles present in it.

Particle size plays a very important role in adsorption process especially in the column studies. First the initial experiments were conducted using the particle size of 0.230mm, but due to fineness of the adsorbent the adsorbate is found to retain the same position without be adsorbed. There is no further development for 15 days, so after a series of discussion it was decided to change the particle size of 0.600mm were used for the columns study. The adsorbate is flowed through the adsorbent and retained in same place and fine adsorption takes place by means of gravity. A series of 7 burettes are taken and the effluent from the first burettes is considered as the influent for the second burette with time interval of 60minutes each. The effluent from the each burette is taken and measured for its optical density. The effluent from the first burette was taken and fed into the second burette as effluent. Similarly the effluents were taken a cyclic process in order to improve their ultimate efficiency. Finally very effective results were found out. In order to correct for any adsorption of colour by the container, control experiments were carried out without adsorbents. It was found that there was no adsorption by the container walls. Similarly same test were carried out by using the filling material, it was also found out that there is no adsorption take place. The entire column tests are conducted at room temperature only.

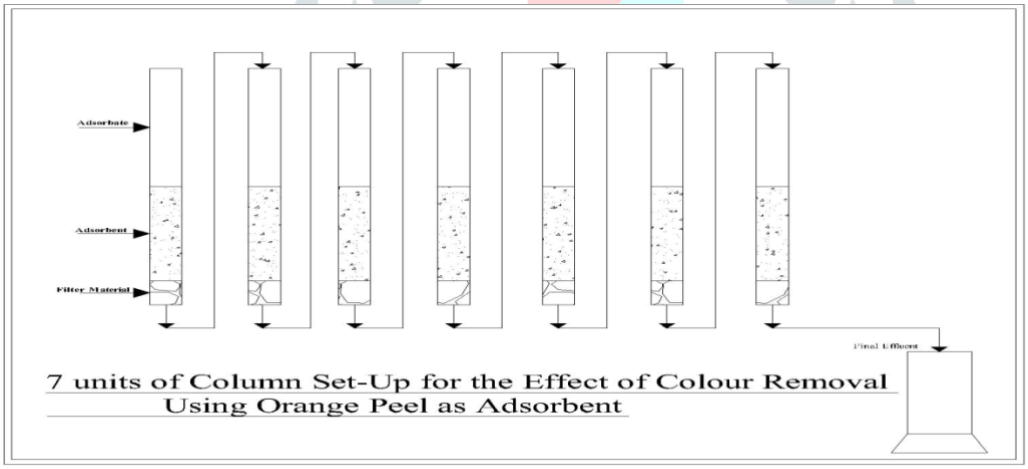

Figure :6 Drawing for the series of column tests conducted using burettes

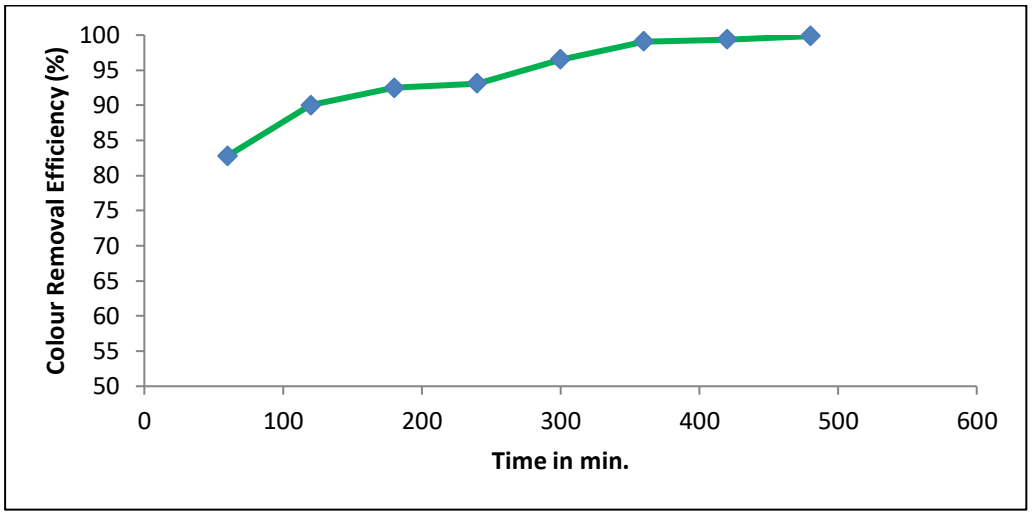

Figure: 7 Graph showing the efficiency of colour removal using burette as column

From the above results on effect on time, effect of adsorbent dosage and effect of pH and column studies, it is found that orange peel is favorable for the adsorption process for colour removal. The other adsorbents also found to be good sorbents.

All the experiments were conducted at the room temperature; more good results can be obtained by studying the effect of temperature and column study by varying then flow rate.

CONCLUSION:

From the obtained data in the present study, it can be concluded that, the adsorption process is a very effective process for the decolorization of textile industrial wastewater. Adjusting some controlling factors will give high result of decolorization. The removal of colour from aqueous solutions and wastewaters using activated carbon and three low cost adsorbent materials orange peel, neem leaves and banana peel were studied. Initial Parameters such as Effect of time and Effect of adsorbent dosage were studied for all the adsorbents in order to find out the effective adsorbent among three, orange peel is found effective next to neem leaves and banana peel. Batch studies and column studies confirm that these low cost materials can be used as a substitute for high cost adsorbent. The adsorption process using orange peel is found be very cost effective compared with activated carbon. It was found that cost of orange peel is two times less than activated carbon. The further scope for the study is to find efficiency of the adsorbent based on varying temperatures.

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