Application of Natural Sugar Cane Bagasse and Coconut Shell in Removal of Dye from Textile Effluent

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***Abstract*—The treatment of dyes in textile industrial wastewaters poses several problems as dyes are generally stable to light and oxidation and hence they cannot be treated by conventional methods of aerobic digestion. Amongst the numerous techniques of pollutant removal, adsorption is an effective and useful process. Specifically when searching for natural raw materials as a possible source that could provide a successful low cost solution for adsorption. This study investigates the potential use of sugar cane bagasse and coconut shells to remove dye from textile effluent through varying adsorbent dosage. With this cheap and eco-friendly adsorbent considerable dye removal can be achieved. So, it can be substituted for expensive activated carbon. With the experimental data obtained in this study, it is possible to design and optimize an economical treatment process for the dye removal from textile industrial effluents.**

Index Terms*— Adsorbent, sugar cane bagasse, Coconut shell. Dye, Effluent

I. INTRODUCTION

Saving water to save the planet and to make the future of mankind safe is what we need now. With the growth of mankind, society, science, technology our world is reaching to new high horizons but the cost which we are paying or will pay in near future is surely going to be too high. Among the consequences of this rapid growth is environmental disorder with a big pollution problem. Anthropogenic activities have caused a great harm to the quality of our lifeline, i.e. water. Because of fast depletion of the freshwater resources, there seems to be a crisis of the same. Water pollution is a global concern and, it is the high time that we realize the gravity of the situation. Removing pollutants from water is the crying need of the hour and developing a cost effective and environmentally safe method to achieve the same. A dye is a coloured substance that has an affinity to the substrate to which it is being applied. Dyes appear to be coloured because they absorb some wavelengths of light more than others. Humans are estimated to use dyes for thousands of years and the earliest use of the colorant is believed to be by Neanderthal man about 1,80,000 years ago . The year 1856 witnessed a historic discovery of first synthetic dye, Mauvine, by Perkin. In due course of time, these synthetic dyes gained huge popularity and began to be synthesized on a large scale. Now-a-days, a large amount of waste water having colour is generated by many industries like textile, leather, paper, printing, plastic and so on. The presence of dye materials greatly influence the quality of water and the removal of this kind of pollutant is of prime importance. Owing to their complicated chemical structures, dyes are difficult to treat with municipal waste treatment operations. Even a small quantity of dye does cause high visibility and undesirability. Moreover, the colour produced by dyes in water makes it aesthetically unpleasant. They can have acute or chronic effects on exposed organisms, which depend on the concentration of the dye and the exposed time. In addition to that, many dyes are considered to be toxic and even carcinogenic. Few decades earlier the dye selection, applications and uses were not given much importance. With the growing health concerns, it was in the 80s that people started paying much attention to the dye wastes. An indication to the magnitude of this problem can be inferred from the fact that two percent of dyes produced are directly discharged into aqueous effluents. With the increased stringent laws on industrial discharge, it has become very important to treat this wastewater. Because of their detriment and large scale distribution in the ecological environment, their separation and determination has become one of the important studies of environmental analysis. Of prime importance is the need for clear information on the safety related properties of the colorants and the measure to be taken for lowering exposure. If all these elements are seriously considered, then the technical use of colorants and the handling involved might be possible without much health danger.

The present study demonstrates the effect of sugar cane bagasse and coconut shell as natural adsorbents for removal of dye from textile industry effluent.

Several physical, chemical and biological de-colorization methods such as coagulation/flocculation treatment, biodegradation processes, oxidation methods, membrane filtration and adsorption have been reported to be investigated for the removal of dyes from industrial effluents. Among the studied methods, removal of dyes from adsorption is found to be the most competitive one because it does not need a high operating temperature and several colouring materials can be removed simultaneously. The versatility of adsorption is due to its high efficiency, economic feasibility and simplicity of design

Thus our objective is to study the effects of sugar cane bagasse and coconut shell (natural adsorbents) in removing the dyes from textile effluent. And to analyse which adsorbent is more effective in waste water treatment.

II. MATERIALS AND METHODS

A. Preparation of material

The collected sugar cane bagasse was washed thoroughly with water to remove the colour and dried in sunlight. The dried bagasse was grind and sieved to the desired particle size and used for adsorption studies.

Fig. 1 Sugar cane bagasse

Fig. 2 Processed Sugar cane bagasse

The dried coconut shell was washed with water for 4 to 5 times, and then it was dried in sunlight. The dried coconut shells were then grind to make it powdered form. Collect powder which is passing through 600 micron sieve and retained on 300 micron.

Fig. 3 Coconut shell

Fig. 4 Coconut shell powder

B. Method of Collection of Effluent

Textile effluent about 6 litres where collected from Kerala Khadi and Villege Industries, Avinissery. The effluent where collected in plastic bottles. Before collection of waste water the bottles where rinsed once with water and dried. During collection time care was taken to avoid the trapping of air with in the bottle. The effluents were stored at $4^{o}C$ during storage period to avoid any change in its characteristics.

The pollutant features of textile wastes differ widely among various Organic substances such as dyes, starches and detergents in effluent undergo chemical and biological changes which consume dissolved oxygen from the receiving stream and destroy aquatic life. Such organics should be removed to prevent septic conditions and avoid rendering the stream water unsuitable for municipal, industrial, agricultural and residential uses.

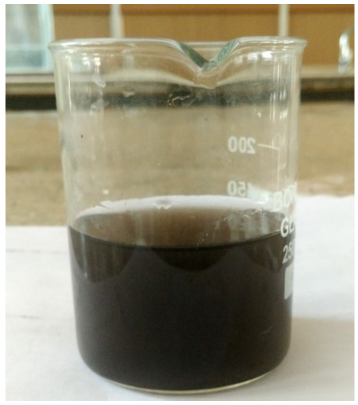

Fig.3 Sample of textile effluent

C. Experimental Work

The dye from textile effluent is removed by using adsorption process. The batch study was performed to determine the optimum condition and to study the adsorbent dose and contact time on the test solution. Each adsorbent with 1g, 2g, 3g, 4g, 5g are mixed with 250ml of effluent to study its effects. At the end of the desired contact time, the samples were filtered using Whatman no. 42 filter paper and the filtrate was analyzed for residual dye concentration by standard method by spectrophotometer. Characteristics of effluent before treating and after treating are also analyzed. The parameters were selected based on the influence of dyes and other chemicals. The parameters include alkalinity, hardness, pH.

Fig.5 Batch process

III. RESULTS AND DISCUSSIONS

The aim of the study is the comparison of application of natural sugar cane bagasse and coconut shell in removal of dye from textile effluent. Most of the adsorption studies have been focused on low cost adsorbents. Some of the advantages of using natural material wastes for waste water treatment include involvement of simple techniques requirement of good adsorption capacity, very little processing, low cost, free availability etc. In this work batch studies are carried out using sugar cane bagasse and coconut shell. The effluent characteristics before treatment and after treatment were analyzed.

TABLE I
Effect on effluent characteristics

Sl.No	Parameters	Effluent readings		
		Before treatment	After treatment	
			Sugar cane bagasse	Coconut shell
1	pH	9.3	8.8	8.3
2	Hardness (mg/L)	160	90	110
3	Alkalinity (mg/L)			
	Hydroxide	0	0	0
	Carbonate	340	250	320
	Bicarbonate	210	175	70
	Total	550	425	390
4	Adsorbance	0.130	0.016	0.024

A. pH

pH is a numerical scale used to specify the or basicity of an aqueous solution. It is approximately the negative of the base 10 logarithm of the molar concentration, measured in units of moles per litre, of hydrogen ions. More precisely it is the negative of the base 10 logarithm of the activity of the hydrogen ion. Solutions with a pH less than 7 are acidic and solutions with a pH greater than 7 are basic. Pure water is neutral, at pH 7 (25 °C), being neither an acid nor a base.The pH of the effluent was obtained as 9.3. When the effluent is treated with sugar cane bagasse and coconut shell the pH is slightly decreased to 8.8 and 8.3. For irrigation purpose the pH should be within 6.0-8.5. So this effluent water after treatment can be used for irrigation purpose on the basis of pH.

B. Hardness

Water hardness is a tradition measure of the capacity of water to precipitate soap. Hardness of water is not specific constituent but is a variable and complex mixture of cations and anions. It is caused by dissolved polyvalent metallic ions. In fresh water the principal hardness causing ions are calcium and magnesium which precipitate soap. Other polyvalent cations also may precipitate soap, but often are in complex from frequently with organic constituents, and their role in water hardness may be minimal and difficult to define. Total hardness is defined as the sum of the calcium and magnesium concentration, both expressed as $CaCO_3$, in mg/L. Hardness is an important aspect in textile waste water. The effluent from textile industry contain higher amount of hardness than the standard irrigation water. So it needs proper treatment before discharge in to surface water. The hardness of the effluent is obtained as 160mg/L and, when it treated with sugar cane bagasse and coconut shell it is observed that the hardness is reduced. And the degree of hardness becomes hard to medium.

C. Alkalinity

Alkalinity of water is its quantitative capacity to neutralise strong acid to designated pH. This is really an expression of buffering capacity. A buffer is a solution to which an acid can be added without changing the concentration of available H+ ions (without changing the pH) appreciably. It essentially absorbs the excess H+ ions and protects the water body from fluctuations in pH. In most natural water bodies the buffering system is carbonate-bicarbonate (H_2CO_3, HCO_3, and CO_3). Alkalinity is usually expressed in mg/L of calcium carbonate ($CaCO_3$).alkalinity of sample can be estimated by titrating with standard sulphuric acid (0.02N) at room temperature using phenolphthalein and methyl orange indicator. Table 1 shows the reduction of alkalinity of effluent with treated with sugar cane bagasse and coconut shell.

D. Effect of Adsorbent Dose

The adsorption of dye increased with the adsorbent dosage for sugar cane bagasse as adsorbent at adsorbent dosage above 3gm/250ml reached equilibrium. For coconut shell the adsorption of dye increased with the adsorbent dosage and at adsorbent dosage above 2gm/250ml reached equilibrium. The percentage of dye removal increased with the increasing amount of biomass. Further increment in adsorbent dose did not affect significant improvement in adsorption. This is due to the binding of adsorbate to the adsorbent and equilibrium is reached between the adsorbate bound to the adsorbent and those remaining unadsorbed in the solution.

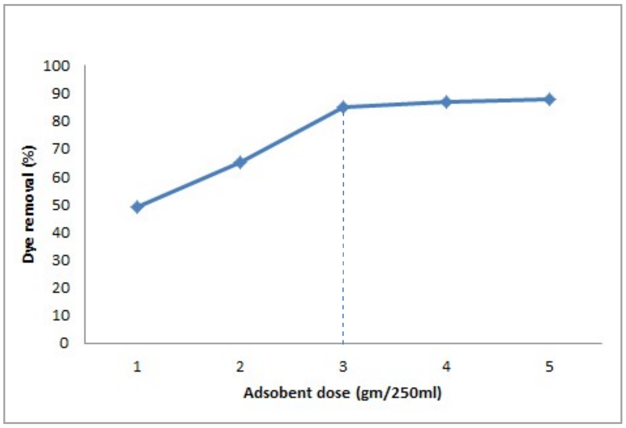

Fig.6 Effect of sugar cane bagasse adsorbent dose

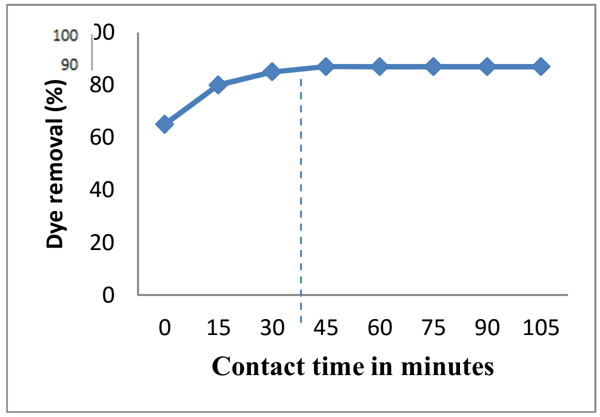

Fig.8 Effect of sugar cane bagasse contact time

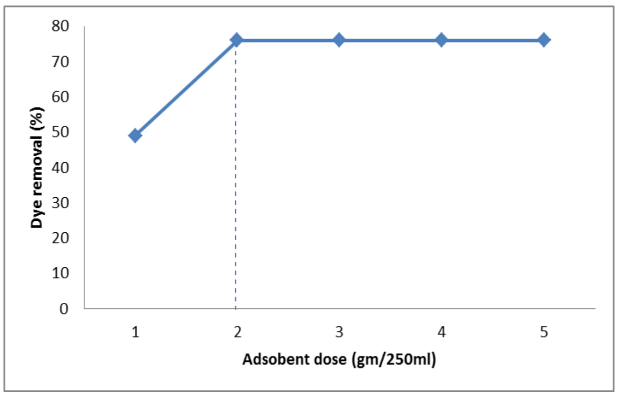

Fig.7 Effect of coconut shell adsorbent dose

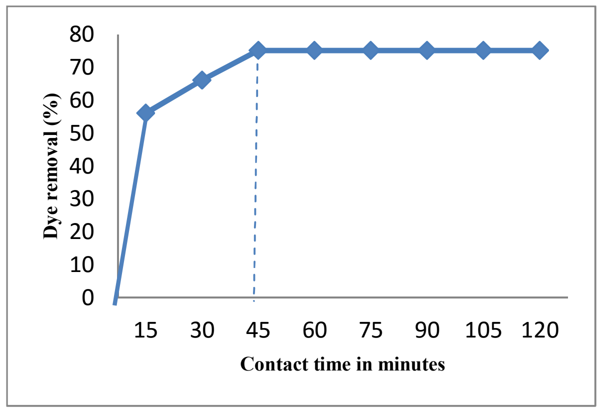

Fig.9 Effect of coconut shell contact time

E. Effect of contact time

Contact time plays a very important role in adsorption dynamics. The effects of contact time on adsorption of dye onto sugar cane bagasse and coconut shell powder are shown in Fig.8 and fig.9. Here different contact time of effluent added with sugar cane bagasse of adsorption dose 3mg/250ml and with coconut shell of adsorbent dosage 2mg/250ml is considered, because this dosage is considered as optimum dosage above this dosage equilibrium is obtained. In adsorption experiment, dye solution was added with adsorbent in shaking jars at room temperature and the blend stirred on a rotary orbital shaker at different rpms. The sample withdrawn from the shaker at the fixed time intervals, then agitated samples from the shaker are tested for its adsorption in UV spectrophotometer to know colour removal efficiency of the adsorbent. The colour removal efficiencies of the adsorbents have a breakthrough at 120minutes duration, in which there is no further considerable colour removal takes place. It is observed that after 60 minutes there is no change in adsorbance when sugar cane bagasse as adsorbent material and after 45 minutes there is no change in adsorbance when coconut shell powder as adsorbent material.

F. Colour removal efficiency

How much colour is removed or colour removal efficiency can be find out by calculating the percentage of colour is removed. It can be calculated by following equation.

$$\text{Percentage removal} = \frac{C_i - C_f}{C_i} \times 100\,\%$$

Where C_i is the initial colour concentration, C_f is the final colour concentration. Here the percentage of colour removal is about 82% in case of sugar can bagasse as adsorbent. And 74% in case of coconut shell powder as adsorbent. From the graphical representation of concentration v/s absorbance the initial colour concentration and final colour concentration can be find out using the corresponding adsorbance value in the standard colour adsorbance and concentration curve. The graph showing these results are given in Fig.10 and Fig.11.

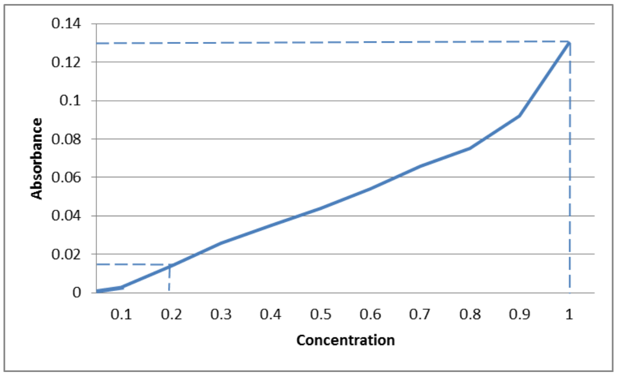

Fig.10 Concentration v/s Absorbance of sugar cane bagasse

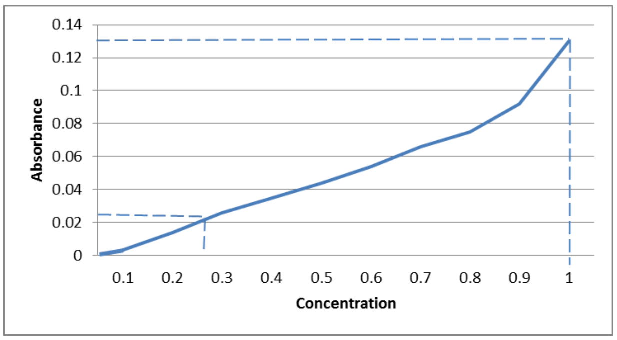

Fig.11 Concentration v/s Absorbance of coconut shell

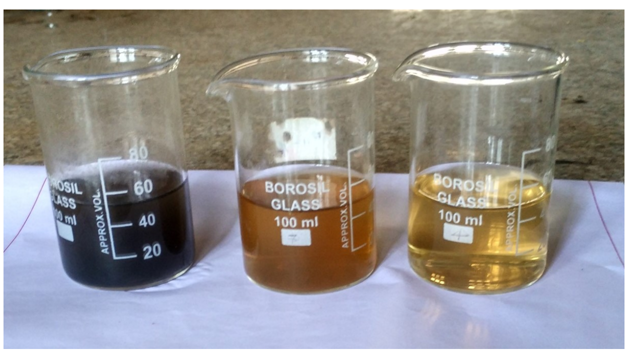

Fig. 11 effluent before treatment, effluent treated with coconut shell and effluent treated with sugar cane bagasse

TABLE II
Characteristics

Sl no.	Parameters	Adsorbent	
		Sugar cane bagasse	Coconut shell
1	Adsorbent Dose (gm/250ml)	3	2
2	Contact Time (min)	60	45
3	Colour Removal Efficiency (%)	82	74

IV. Conclusions

In this study we used sugar cane bagasse and coconut shell as an adsorbents in removal of colour from textile effluent. The aim of the study was to investigate the cost effective natural material to remove colour from textile effluent. Batch adsorption study was investigated for the removal of dye from textile effluent. And it is observed that adsorbents are very efficient in decolorized effluent. The optimum contact time and optimum adsorbent dosage for sugar cane bagasse and coconut shell powder were found out. For sugar cane bagasse optimum adsorbent dose is 3gm/250ml and coconut shell is 2gm/250ml. For sugar cane bagasse optimum contact time is 60min and coconut shell is 45min. Both sugar cane bagasse and coconut shell can highly remove colour from textile waste water. Sugar cane bagasse remove about 82% and coconut shell powder remove 74%.It was found that better removal efficiency could be achieved by sugar cane bagasse method. These methods also reduce the hardness and alkalinity of the effluent.

With the experimental data obtained in this study, it is observed as it is possible to design and optimize an economical treatment process for the dye removal from textile effluents using cheap natural waste materials which are easily available.

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