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Colour Removal from Textile Industry Wastewater Using Low Cost Adsorbents

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ABSTRACT
In this study, the experiments were performed to investigate the adsorption capacities of locally available low cost bio-adsorbents like neem leaves, orange peels, peanut hulls and coconut coir pith powders to remove colour in a textile industry wastewater. Conducted the experiments at pH of 7 with different process parameters like adsorbent dosage, temperature, contact time and agitator speed using batch adsorption method. From the experimental investigations, the maximum colour from the textile industry wastewater was obtained at an optimum adsorbent dosage of 300 mg, an optimum contact time of 75 min., an optimum temperature of 330 K and an optimum agitator speed of 600 rpm.Further, from the validation experiments, it was found that the maximum colour removal percentage in textile industry wastewater is about 74.2, 79.3, 85.6 and 80.7 % respectively for neem leaves, orange peels, peanut hulls and coconut coir pith powders. This result was higher than the results obtained by different process parameters for various bio-adsorbents. Finally, from the results of adsorption study, it was concluded that bio-adsorbents used as a coagulant for removing the colour from textile industry wastewater especially peanut hulls powder because of its higher adsorptive capacity than other bio-adsorbents used in this study.
Keywords: Textile Industry Wastewater, Bio-Adsorbents, Process Parameters

INTRODUCTION
One of industry that plays an important role in the economy of several countries is textile industry. Textile industry classified into three categories viz., vegetable fibers such as cotton; animal fibers such as wool and silk; and a wide range of synthetic materials such as nylon, polyester, and acrylics depending upon the raw materials used. The raw materials used in the textile industry determine the volume of water required for production as well as wastewater generated [11]. Thus, the biggest impact on environment by textile industry is consumption of water and generation of wastewater. The wastewater generated from the various processing units are desizing, scouring, bleaching, mercerizing, dyeing, printing, and packing. These processes require huge amount of organic chemicals of complex structure [15, 24] and all of them are not contained in the final product, became waste and caused disposal problems [11]. The wastewater resulting from these processes differ greatly in composition, due to differences in processes, used fabrics and machinery [6]. The main parameters identified in the textile industry are biological oxygen demand (BOD), chemical oxygen demand (COD), colour, pH and other solution substances [24]. When compared to other parameters, the treatment for BOD, COD and colour removal can increase the risk. Therefore, treat the wastewaters from the dyeing units before discharge to the environment [21].

Currently, various physicochemical, coagulation [25], oxidation, precipitation, filtration, electrochemical treatment [14], ozonation [13], chemical precipitation, membrane filtration, hydrogen peroxide, reverse osmosis [7] and biological techniques can be employed to remove the BOD, COD and colour from wastewater [9]. Due to the high cost and disposal problems involved in the above said methods, further investigation of new techniques have been come up. The adsorption process provides [22]an attractive alternative to the above processes because of inexpensive and readily available [5, 8] to control the various pollutants from the water and wastewater. Exploration of good low cost and non-conventional adsorbents may contribute to the sustainability of the environment and offer promising benefits for the commercial purpose in future. The costs of the activated carbon prepared from biomaterials are negligible when compared to the cost of commercial activated carbon. Some of the activated carbons used to treat the industrial wastewater in the recent past are, corncob, groundnut husk, rice husk, tea leaves carbon, saw dust [1, 18] eucalyptus bark [4], agricultural wastes and spent activated carbon [26]. When compared to other pollutants in the textile industry wastewater, colour removal had been the target of significant attention in the last few years, not only because of its toxicity, but also mainly due to its visibility problems and non-biodegradable characteristics [2, 9]. Further, colour from textile industry is having more resistance to removal by the microorganisms present in the industrial wastewater treatment plants. Many investigators have examined a wide variety of absorbents like fly-ash [20, 23], peat, sawdust, brown coal, bagasse, [16], activated carbon [10, 12] to remove colour from textile industry wastewater [17, 19] rather than removal of BOD and COD in the textile industry wastewater. This study was conducted to investigate the adsorption capacities of locally available low cost adsorbents like neem leaf, orange peels, peanut hulls and coconut coir pith powders to remove the colour in textile industry wastewater. This study was conducted in the month of July 2011 at Environmental Engineering Laboratory of Department of Civil Engineering, Vel Tech High Tech Dr.Rangarajan Dr.Sankunthala Engineering College, Tamil Nadu, India.

METHODS AND MATERIALS

Adsorbent and Coagulant Preparation

The low cost bio-absorbents like neem leaves, orange peels, peanut hulls and coconut coir pith were collected from the local areas and washed repeatedly with distilled water to remove dust and soluble impurities. Initially all bio-adsorbents were kept for drying at room temperature in a shade for 10 h and then heating in an air oven at 473 K for 24 h. Then they crushed and passed through 15-20 mesh. Then, the prepared neem leaves, orange peels, peanut hulls and coconut coir pith powders were kept in a refrigerator at a temperature of 278 K. This method used to avoid the decomposition, because neem leaves, orange peels, peanut hulls and coconut coir pith powders are agro-based products.

Collection and Analysis of Textile Industry Wastewater

For the present study, collected a textile industry wastewater samples from final clarifier of textile industry wastewater treatment plant of Chennai city, Tamil Nadu, India with the help of airtight sterilized bottles. Then, took the wastewater samples to the Environmental Laboratory and then they were stored in refrigerator at 278 K for analyzing colour intensity. In order to reduce the colour in a textile industry wastewater, selected various bio-adsorbent like neem leaves, orange peels, peanut hulls and coconut coir pith powders. Further, conducted the experiments by different process parameters like adsorbent dosage, temperature, contact time and agitator speed. The colour removal percentage in a textile industry wastewater was calculated as per standard procedures stipulated by [3].

Adsorption Experiments

Conducted batch adsorption experiments by shaking a series of five glass bottles containing 250 ml textile industry wastewater with different adsorbent dosage (100, 200, 300, 400 and 500 mg), different contact time (25, 50, 75, 100 and 125 min.), different temperature (300, 310, 320, 330 and 340 K) and different agitator speed (200, 400, 600, 800 and 1000 rpm). The bottles were tightly fixed in the shaker. The shaking proceeded for 3 hrs to establish equilibrium, after which the mixture was left to settle for 1 h. The filtrate's absorbance was determined by means of the Elico-UV spectrophotometer, SL 150 adjusted at λ_{max} (Fig.1). By referring to the calibration curve of the absorbance, the percentage reduction of colour from a textile industry wastewater could be obtained. The absorbance and calibration curves are represented in the Fig.1 and Fig.2 respectively. From Fig.1, it may be observed that upto some wavelength absorbance increased with wavelength increased, beyond which, the absorbance decreased. The point at which the absorbance decreased is called point of deflection and the wavelength corresponding to the point of deflection is called maximum wave length. The observed maximum wavelength from Fig.1 is 495 nm. Fig.2 indicated calibration curve for textile industry wastewater at a wavelength of 495 nm and it may be observed that as a dilution factor increased absorbance decreased linearly with R^2 value of 0.998 and Fig.2 is used for finding the colour removal efficiency at different process parameters.

RESULTS AND DISCUSSIONS

The different process parameters like adsorbent dosage, temperature, contact time and agitator speed has been selected for conducting batch adsorption study to reduce colour in a textile industry wastewater. The colour removal in a textile industry wastewater was achieved by using bio-adsorbents like neem leaves, orange peels, peanut hulls and coconut coir pith powders. The experimental results from effect of different process parameters like adsorbent dosage, temperature, contact time and agitator speed are as follow.

Effect of Adsorbent Dosage

Fig.3 show the percentage reduction of colour in a textile industry wastewater with pH of 7 against absorbent dosage from 100 to 500 mg (Fig.3) with an increment of 100 mg by different bio-adsorbents at contact time of 60 min., temperature 300 K and agitator speed of 400 rpm. The results revealed that colour removal percentage was low at the beginning and then increased with adsorbent dosage increased. This is because, the active sites in the bio-adsorbents could not be effectively utilized when the dosage was low and thereafter bio-adsorbents could be effectively utilized. When the bio-adsorbent dosages are higher, it is more likely that a significant portion of the available active sites remain uncovered, leading to lower specific uptake. From Fig.3 it may be found that an optimum adsorbent dosage at which maximum colour removal is 300 mg and the colour reduction percentage is 72.8, 78.0, 83.5 and 79.5 % respectively for neem leaf, orange peels, peanut hulls and coconut coir pith powders.

Effect of Contact Time

Fig.4 show the percentage reduction of colour in a textile industry wastewater with pH of 7 against contact time from 25 to 125 min. (Fig.4) with an increment of 25 min. by different bio-adsorbents at an optimum adsorbent dosage of 300 mg (Fig.3), temperature of 300 K and agitator speed of 400 rpm. The results revealed that the rates of percent colour removal are lower at the beginning of the experiment is probably due to the larger surface area of bio-adsorbents was not contacted properly with the textile industry wastewater. Further, as contact time increased, the colour removal percentage also increased, is due to larger surface area of bio-adsorbents was contacted properly with a textile industry wastewater. As surface adsorption sites become exhausted, uptake rate is controlled and transported the adsorbate from the exterior to interior sites of bio-adsorbents. From Fig.4, it may be found that an optimum contact time at which maximum colour removal is 75 min. and colour reduction percentage is 71.5, 74.0, 80.6 and 76.6 % for neem leaf, orange peels, peanut hulls and coconut coir pith powders respectively.

Effect of Temperature

The effect of temperature onto colour removal in a textile industry wastewater with pH of 7 by different bio-adsorbents was investigated at a temperature from 300 to 340 K (Fig.5) with an increment of 10 K and at an optimum adsorbent dosage of 300 mg (Fig.3), an optimum contact time of 75 min. (Fig.4) and agitator speed of 400 rpm. The percentage of colour removal continuously increased as temperature increased. However, maximum colour removal was obtained at a temperature of 330 K and thereafter equilibrium was attained. Increasing the temperature is known to increase the rate of diffusion of the adsorbate molecules across the external boundary layer and in the internal pores of the adsorbents particle, owing to the decrease in the viscosity of the solution. Thus, a change in temperature will change the equilibrium capacity of the adsorbents for a particular adsorbate. From Fig.5, it may be found that an optimum temperature at which maximum colour removal is 330 K and colour reduction percentage is 72.8, 76.2, 81.5 and 77.9 % for neem leaf, orange peels, peanut hulls and coconut coir pith powders respectively.

Effect of Agitator Speed

The influence of agitator speed onto colour removal in a textile industry wastewater with pH of 7 by different bio-adsorbents (Fig.6) was examined at a agitator speed from 200 to 1000 rpm with an increment of 200 rpm and at an optimum adsorbent dosage of 300 mg (Fig.3), an optimum contact time of 75 min. (Fig.4) and an optimum temperature of 330 K (Fig.5). It can be seen that continuous increment in percentage removal with increasing agitator speed upto 600 rpm, beyond which colour removal attained the equilibrium. From Fig.6, it may be found that an optimum agitator speed at which maximum colour removal is 600 rpm and colour reduction percentage is 73.8, 76.9, 82.3 and 78.4 % for neem leaf, orange peels, peanut hulls and coconut coir pith powders respectively.

Verification Experiment

In order to validate the above experiments in reducing the colour from textile industry wastewater, a separate experiment has been performed with an optimum adsorbent dosage of 300 mg (Fig.3), an optimum contact time of 75 min (Fig.4), an optimum temperature of 330 K (Fig.5) and an optimum agitator speed of 600 rpm (Fig.6). The maximum colour removal percentage by different bio-adsorbents in a textile industry wastewater is shown in Fig.7. The results (Fig.7) showed that maximum colour removal percentage in a textile industry wastewater is about 74.2, 79.3, 85.6 and 80.7 % respectively for neem leaves, orange peels, peanut hulls and coconut coir pith powders. Furthermore, it may also be found from Fig.7 that the maximum colour removal percentage in a textile industry wastewater was higher than each selected process parameters (Figs.3 to 6) of different bio-adsorbents. Based on the results, it was concluded that bio-adsorbents may be used for removing the colour in a textile industry wastewater. Furthermore, over all experimental results (Figs.3 to 7) at different process parameters have shown that maximum adsorption capacity of bio-adsorbents in the order of colour removing from textile industry wastewater is peanut hulls powder followed by coconut coil pith powder, orange peels powder and neem leaves powder.

CONCLUSIONS

In the present study, the batch adsorption study was conducted to find out suitability of bio-adsorbents for removing colour in a textile industry wastewater. The ability of bio-adsorbents for removing colour in a textile industry wastewater with different dosage, different contact time, different temperature and different agitator speed were monitored for this present study. The maximum percentage reduction of colour in a textile industry wastewater by different bio-absorbent were obtained at an optimum adsorbent dosage of 300 mg, an optimum contact time of 75 min., an optimum temperature of 330 K and an optimum agitator speed of 600 rpm. From the validation experiments, it found that maximum colour removal percentage in a textile industry wastewater is about 74.2, 79.3, 85.6 and 80.7 % respectively for neem leaves, orange peels, peanut hulls and coconut coir pith powders. These results of validation experiment were higher than the results obtained by different process parameters. Furthermore, over all experimental results have shown that maximum adsorption capacity of bio-adsorbents in the order of colour removing from a textile industry wastewater is peanut hulls powder followed by coconut coil pith powder, orange peels powder and neem leaves powder. Finally, from the results of adsorption study, it was concluded that bio-adsorbents may be used as a coagulant for removing colour from a textile industry wastewater especially peanut hulls powder because of its higher adsorptive capacity than other bio-adsorbents used in this study.

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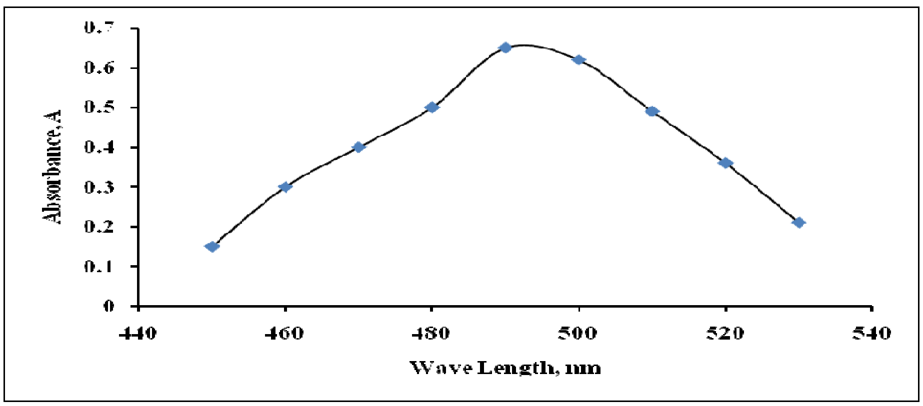

Fig.-1: Absorbance Curve for Textile Industry Wastewater

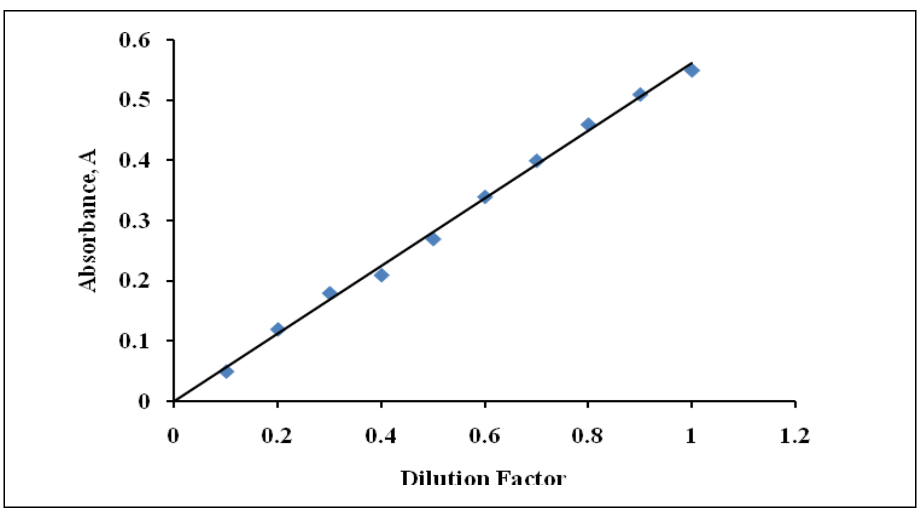

Fig.-2: Calibration Curve for Textile Industry Wastewater
at a Wave Length of 495 nm

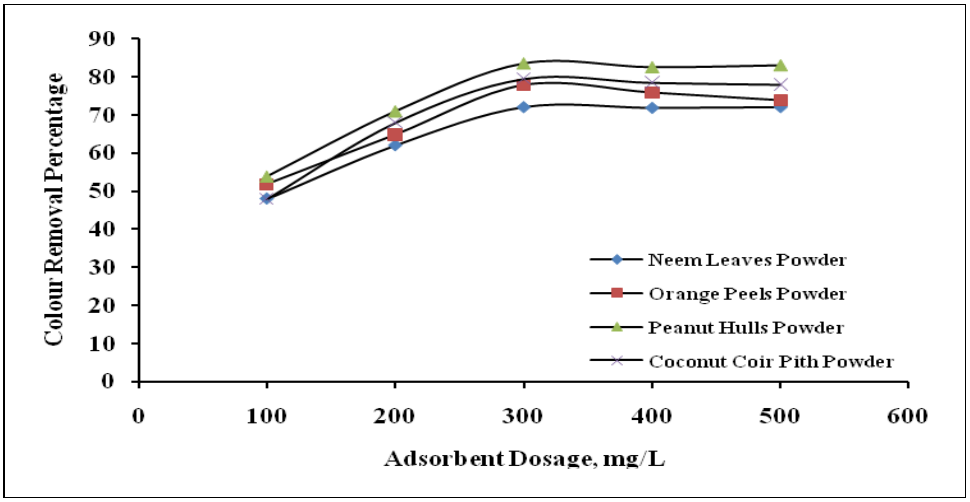

Fig.-3: Effect of Adsorbent Dosage on Colour Removal

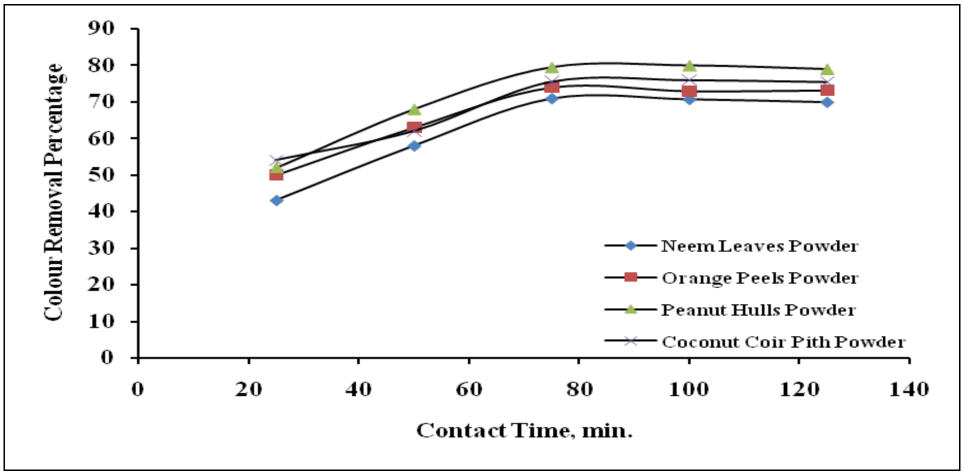

Fig.-4: Effect of Contact Time on Colour Removal

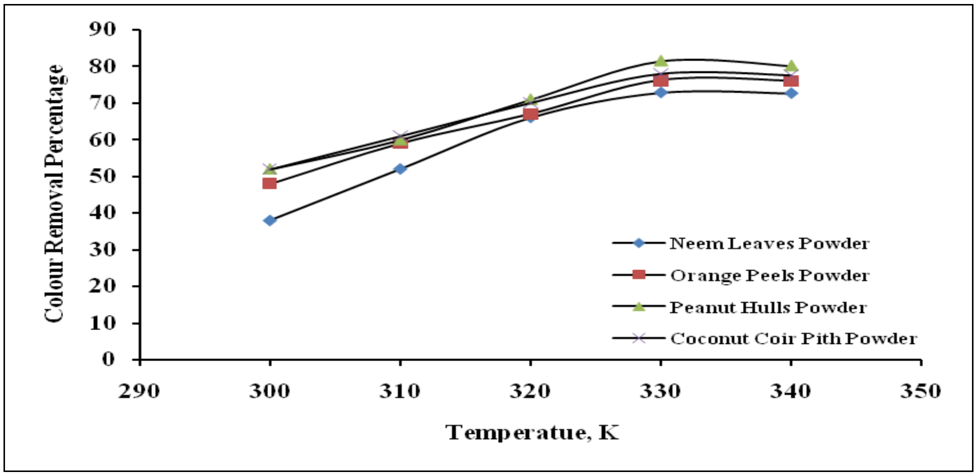

Fig.-5: Effect of Temperature on Colour Removal

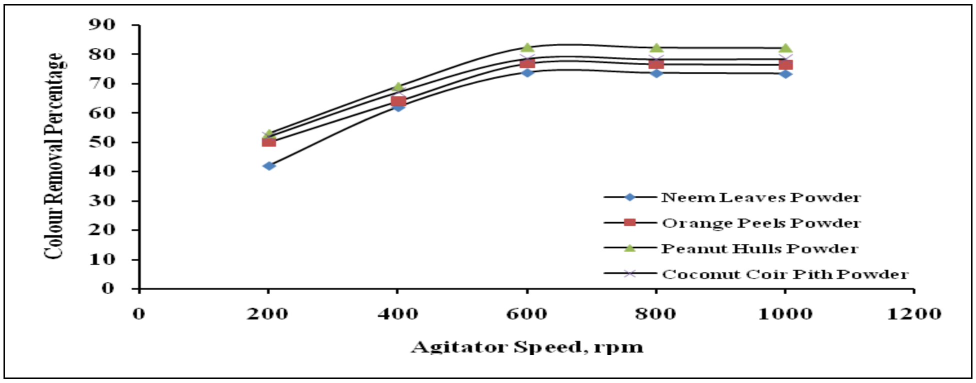

Fig.-6: Effect of Agitator Speed on Colour Removal

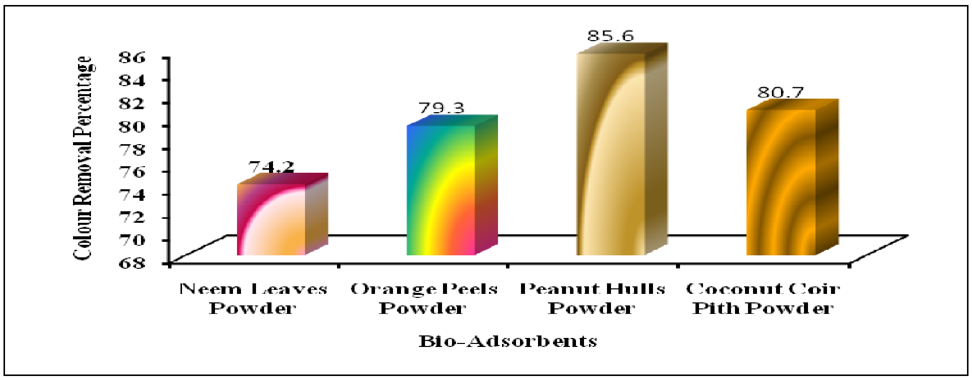

Fig.-7: Maximum Colour Removal Percentage by Different Bio-Adsorbents

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