EXPERIMENTAL STUDY OF METHYLENE BLUE DYE ADSORPTION USING CASHEWNUT SHELL AS AN ALTERNATE ADSORBENT

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Abstract— Colored compounds are the most easily recognizable pollutants in the environment because of their appearance. Most of the industries such as textile, paper, carpet, and printing use dyes and pigments to color their products. Due to their good solubility, synthetic dyes are common water pollutants and they may frequently be found in trace quantities in industrial wastewater. However, the discharge of dye-bearing wastewater into natural streams and rivers possess a severe problem, as dyes impart toxicity to aquatic life and are damaging the aesthetic nature of the environment. However, wastewater containing dyes is very difficult to treat, since the dyes are recalcitrant organic molecules, resistant to aerobic digestion, and are stable to light, heat and oxidizing agents due to their structure and molecular size. Adsorption techniques have gained favor in recent years because of their proven efficiency in the removal of pollutants from effluents too stable for conventional treatment methods. Apart from the high quality product obtained, the processes have proved economically feasible. In many textile processing industries, activated carbon is used as a sorbent to remove dyes in wastewater due to its excellent adsorption ability. For the study presented here Activated carbon (Commercial), Charcoal (Cashew-nut shell) and Charcoal (Wood) were used as an adsorbent. The experimental investigations have been made to find the effect of various parameters on the change in concentration of dye and to find the inexpensive alternative adsorbents in order to decrease the cost of treatment.

Keywords: Synthetic Dyes, Adsorption, Effluents, Adsorbent

I. INTRODUCTION

Textile processing industries now days are widespread sectors in developing countries. Among the various processes in the textile industry, dyeing process uses large volume of water for dyeing, fixing and washing processes. Thus, the wastewater generated from the textile processing industries contains suspended solids, high amount of dissolved solids, un-reacted dyestuffs (colour) and other auxiliary chemicals that are used in the various stages of dyeing and processing. The conventional method of textile wastewater treatment consists of chemical coagulation, biological treatment followed by activated carbon adsorption. The conventional coagulation process generates huge volume of hazardous sludge and poses a problem of sludge disposal. Textile industry causes considerable higher impacts to water pollution by discharging their effluents into various receiving bodies includes ponds, rivers and other public sewer. Major pollutants load from the textile industries are from the several of their wet-processing operations like scouring, bleaching, mercerizing and dyeing. Usually, dyes contain aromatic rings in chemical structures and therefore, have high stability against light, oxidants, and biological degradation. Thus reduction of dye and chemical oxygen demand (COD) from textile wastewaters are difficult. There are various kinds of physical, biological, and chemical processes to remove dyes from colored wastewater [1].

Amongst the numerous techniques of dye removal, adsorption is the procedure of choice and gives the best results as it can be used to remove different types of coloring materials. The adsorption system if designed correctly will produce a high-quality treated effluent. Most commercial systems currently use activated carbon as sorbent to remove dyes in wastewater because of its excellent adsorption ability. The successful removal of acid dyes by fixed beds of activated carbon has been demonstrated by Walker and Weatherly. Activated carbon (powdered or granular) is the most widely used adsorbent because it has excellent adsorption efficiency for organic compounds, but its use is usually limited due to its high cost. In order to decrease the cost of treatment, attempts have been made to find inexpensive alternative adsorbents [2].

II. THEORY

The color manufacturing industry represents a relatively small part of the overall chemical industry. Man has used natural colorants since prehistoric times. Colorants are characterized by their ability to adsorb or emit light in the visible range (400 – 700 nm. Therefore, it is the reasons they appear to be colored. Colorants include both dyes and pigments. Pigments are insoluble in the materials that they are used to color, whereas most dyes are soluble in them. The most important, difference between pigments and dyes is that pigments are used as colorants in the physical form in which they are manufactured [3]. Pigments particles have to be attached to substrates by additional compounds, such as by a polymer in paint. Dyes, on the other hand are applied to various substrate (textile materials, leather, paper and hair) from liquid in which they completely, or at least partly soluble. In contrast to pigments, dye must possess a specific affinity to the substrates for which they are used [4]. Conventional dyeing of textile substrate is an energy intensive process.

It requires huge amount of energy as well as time to accomplish the process. A number of research studies have been carried to study the effects of non-conventional dyeing techniques on the reaction rates and quality parameters of dyed fabric. Some studies have also been made on the consumption of water, energy, chemicals etc. Schuler (1957) investigated the mechanism of carrier action in dyeing Dacron polyester fiber [5].

Earlier, synthetic dyes are used in textile industries only but now a day's these dyes serve many industries such as; Medicine, chemistry, plastics, paint, printing ink, rubber, cosmetics etc.

A. Factors affecting adsorption

There are several important factors affecting adsorption such as,

Contact time/residence time: The longer time, the more complete adsorption will be. However, the equipment will be larger [6]. The adsorption of SB dye onto composite adsorbed has been investigated as a function of time in the range of 1-30 min. A higher removal percentage of textile dyes is obtained at the beginning of the adsorption. Percent adsorption decreases sharply with increasing shaking time.

Particle size of adsorbent: Small particle sizes reduce internal diffusion and mass transfer limitation to the penetration of the adsorbate inside the adsorbent (i.e., equilibrium is more easily achieved and nearly adsorption capability can be attained).

Solubility of solute (adsorbate) in liquid (wastewater): It will be more easily removed than polar substances since the latter have greater affinity for water.

Degree of ionization of the adsorbate molecule: More highly ionized molecules are adsorbed to smaller degree than neutral molecules.

pH: The degree of ionization of a species is affected by pH (e.g., a weak acid or a weak basis) this in turn affects adsorption.

Temperature: Temperature also can affect adsorption process. A study of the temperature dependence of adsorption reactions gives valuable information about the enthalpy and entropy changes during adsorption. Greater adsorption is often found at lower temperatures**.** In general, the use of adsorbents for adsorption process depends on cases.

B. Advantages of Adsorption over other Methods

Colour in dye house effluents has always been a difficult problem to solve and the utilization of dyes has made it even more serious [7]. Cooper (1993) summarized the technologies used until then in order to remove or at least reduce colour, mentioning that some them have certain efficiency: Coagulation and/or flocculation, membrane technologies, chemical oxidation technologies, biochemical oxidation and adsorbent utilization. Among various treatment technologies, adsorption onto activated carbon has proven to be one of the most effective and reliable physicochemical treatment methodologies [8, 9, 10]. The adsorption process has an edge over the other treatment methods due to its sludge free operation, and complete removal of dyes even from dilute solutions. The wide usefulness of activated carbon is a result of its chemical and mechanical stability, high adsorption capacity and high degree of surface reactivity.

III. MATERIAL AND METHOD

A. Material

Adsorbent used for the experimentation were Activated carbon (Commercial Grade), Charcoal (Prepared from Cashew-nut shell) and Charcoal (Prepared from Wood), and Methylene blue was used to prepare the dye solution.

B. Preparation of Adsorbent

The preparation of Adsorbent from cashew-nut shell was carried out by following method;

Washing: The samples of Cashew-nut shell were collected from Konkan region of Maharashtra State. The collected samples of Cashew- nut shell were washed with water (2 to 3 times) to remove the dust particles and to remove the sticky material.

Drying: After washing, sample was placed on filter paper to remove the water and oil content and placed in sunlight for 4 to 5 days for complete removal of oil.

Grinding: To obtain fine powder the sample was crushed in a mixer. The crushed sample contains large amount oil which is removed by extraction process.

Extraction: Soxhlet Extractor is used to remove the oil content in cashew-nut shell. After extraction, oil is totally removed from the sample.

Heating: After removing oil, the sample needed to heat in absence of oxygen which is done in Muffle Furnace for 1 hour at 220˚C.

Figure 1: Prepared Charcoal from Cashew-nut shell

C. Method

The progress of treatment was monitored by collecting samples of 10-15 ml after every 10 min. Collected samples were then filtered to eliminate sludge formed during process and were examined for absorbance. The dye absorbance was determined using Spectrophotometer (Labtronics LT-290) at λ_{max} 460 & 410 nm, according to Beer-Lambert law, using UV/vis spectrophotometer. The dye used for experiments such as Methylene Blue was purchased from local dyeing industry.

Figure 2: Experimental laboratory Batch Setup at room temperature and in water bath

D. Experimental Procedure

25 ml Methylene blue solution with two different concentrations of 2% and 5% has been prepared in the test tubes. 2gm each of Activated carbon, coal and Cashew-nut were added in the Methylene blue dye solution. The addition of adsorbent was carried out at room temperature and in the water bath at a temperature of 44.5˚C to study the effect of temperature. Then the test tube containing mixture of Methylene blue dye solution and adsorbent is allowed to settle and after successive 10 min interval the samples were collected. The collected samples were filtered and analyzed on spectrophotometer to measure the value of absorbance.

IV. RESULTS AND DISCUSSION

A. Methylene Blue dye with 2% Concentration and at room temperature

At 2% concentration of Methylene Blue dye, in figure 1, the plot of absorbance vs time shows higher drop in concentration of dye when activated carbon was used as an adsorbent. While the other two adsorbents (Cashew nut and Coal) shows lower drop in concentration of dye as compared to activated carbon and have almost same value of absorbance.

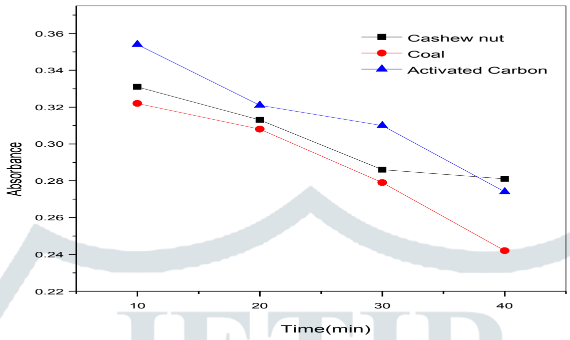

Figure 1: Absorbance vs Time for 2% Concentration of Methylene Blue Dye at room temperature

B. Methylene Blue dye with 5% Concentration and at room temperature

Figure 2 shows the plot of absorbance vs time for 5% concentration of Methylene Blue dye which indicates higher drop in concentration of dye when Cashew nut was used as an adsorbent. While the other two adsorbents (Activated carbon and Coal) shows lower drop in concentration of dye as compared to activated carbon.

C. Methylene Blue dye with 2% Concentration and at elevated temperature (44.5^{0}C)

To investigate the effect of temperature on the absorbance, 2% concentration of Methylene Blue dye was treated with all the adsorbents at an elevated temperature of 44.50C in a water bath. In figure 3, the plot of absorbance vs time shows higher drop in concentration of dye when activated carbon was used as an adsorbent. While at elevated temperature, coal shows least drop in concentration of dye as compared to Cashew nut and Activated carbon.

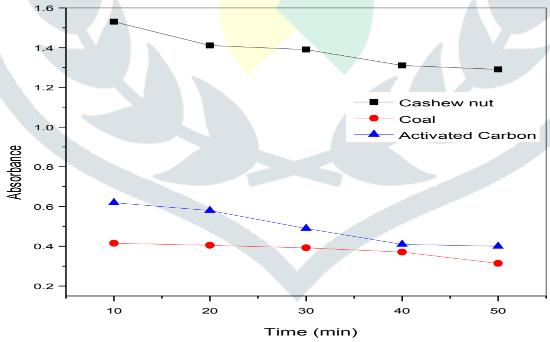

Figure 2: Absorbance vs Time for 5% Concentration of Methylene Blue Dye at room temperature

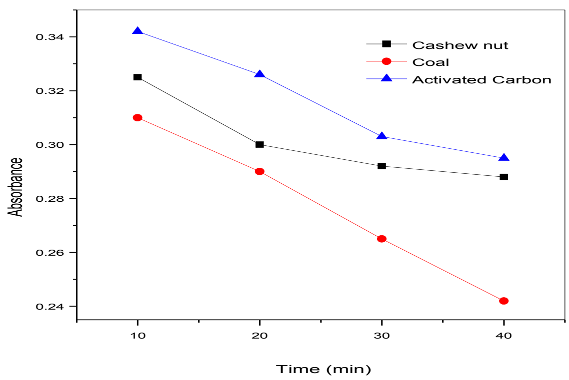

Figure 3: Absorbance vs Time for 2% Concentration of Methylene Blue Dye at elevated temperature

V. CONCLUSION

Activated carbon is giving better result than the adsorbent prepared from cashew nut and coal. It is observed that for the experiments performed at room temperature are having higher drop in concentration for Activated carbon than at elevated temperature. This indicates that the rate of adsorption is greater at room temperature than that of elevated temperature. Experimentally it is observed that the concentration of dye affects the results of adsorption. At 5% concentration of dye, the rate of adsorption for Activated carbon is more as compared to 2% concentration of dye. Whereas for other two adsorbents, the percent drop in concentration is almost same for 2% as well as 5% concentration of dye. The present experimental study with different adsorbents has also been performed to find inexpensive alternate adsorbents in order to decrease the cost of treatment. Cashew nut is showing satisfactory results at different concentration of dye and temperature conditions. Since, Cashew nut shells are readily available in the tropical region of India and preparation of charcoal from it is cheaper, it can be used as an alternative adsorbent.

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