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COLOR REMOVAL FROM INDUSTRIAL WASTEWATER BY ADSORPTION USING BANANA LEAVES ASH

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ABSTRACT

This paper presents the feasibility of removal of basic dye Methylene Blue from aqueous solutions by using a low cost natural adsorbent banana leaves ash in batch adsorption technique. The adsorption experiments were carried out under different conditions of shaking time, shaking speed, pH, incubation temperature and centrifuging time. All batch experiments were carried out with adsorbent dosage of 16 mg/100 ml of aqueous solution of dye. It was found that banana leaves ash with particle sizes varying from 0.053-0.075 mm was found to have a high adsorptive capacity towards Methylene blue dye and show favourable adsorption of MB dye. The highest removal of color is 87.66% was obtained through the experiment by shaking at 350 rpm for 3 hours, 6.30 pH and 30^{o}C temperature. Therefore, it could be mentioned that the banana leaves ash can be used as locally available low cost adsorbent for the removal of synthetic dye from dying industry effluent.

Keywords: *Wastewater, Adsorption, Color removal, Banana leaves ash, Batch adsorption.*

1. INTRODUCTION

During the last few decades the mobility and distribution of dyes in water have been studied extensively due to their toxic effects to humans, animals, plants and the aquatic organisms. Many of the industries, such as dyestuffs, textile, paper, leather, foodstuffs, cosmetics, rubber and plastics are using enormous quantity of synthetic dyes in order to give colour for their products and consume substantial volumes of water. It is estimated that there are about 10,000 different commercial dyes and pigments exist and over $7x10^5$ tones of synthetic dyes are produced annually world-wide (Shitu and Ibrahim, 2014). Approximately 40,000 tonnes of dyes out of roughly 450,000 tonnes in total production are not used but discharged into wastewaters. A large variety of dyestuffs is available under the categories of acid, basic, reactive, direct, disperse, sulphur and metallic dyes. Textile and dyeing industry are among important sources for the continuous pollution of the aquatic environment. Because they produce approximately 5% of them, end up in effluents. The textile and dyeing industries effluents are discarded into rivers, ponds and lakes; they affect the biological life various organisms.

Dye-containing effluents are undesirable wastewaters because they contain high levels of chemicals, suspended solids, and toxic compounds. Colour causing compounds can react with metal ions to form substances which are very toxic to aquatic flora and fauna and cause many water borne diseases. The color is the first contaminant to be recognized in wastewater. Effluents with small amounts of dye can cause local environmental problems and at the same time might significantly affect the aquatic life, leading to decrease growth of bacteria and hence decreasing the bio-degradation of impurities in water. The release of untreated colored wastewater into the ecosystem can seriously be damaging to the receiving water bodies. The presence of even very small amounts of dyes in water (less than 1ppm for some dyes) is highly visible and undesirable (Banat, et al, 1996). Because of their synthetic and toxic nature, dyes have a severe impact on human health, causing many problems, such as allergies, dermatitis, skin irritation, caner and mutations (Nasuha, et al., 2010). Hence, it is necessary to treat the industrial effluents to reduce the concentration of color prior to its release into environment.

Various methods of dye/color removal such as aerobic and anaerobic microbial degradation, coagulation, and chemical oxidation, membrane separation process, electrochemical, dilution, filtration, flotation, softening, adsorption and reverse osmosis have been proposed from time to time. The advantages and disadvantages of each method have been extensively reviewed (Lorenc et al., 2007; Cooper, 1993). However, all of these methods suffered with one or more limitation and none of these were successful in removing color from the wastewater completely. Although biological treatment processes remove biochemical oxygen demand (BOD), chemical oxygen demand (COD) and suspended solids (SS) to some extent, they are largely ineffective in removing color from wastewater because most of these are toxic to the organisms used in the process. The coagulation process effectively decolorizes insoluble dyes but fails to work well with soluble dyes. Photochemical degradation in aqueous solution is likely to progress slowly because synthetic dyes are in principle designed to possess a high stability to light. Accordingly, the removal of dyes from effluent in an economic fashion remains a major problem. The convectional biological treatment process is not very effective in treating a dyes wastewater, due to low biodegradation of dyes. However, these processes were very expensive and could not be effectively used to treat the wide range of dyes waste (Garg and Babu, 2003).

Many of the methods are available for the removal of pollutants from water, of these methods, adsorption technique is a most versatile and widely used technique (Gupta et al, 2009), because of its inexpensive nature and ease of use. It is an effective method of lowering the concentration of dissolved dyes in the effluent resulting in color removal. Adsorption systems are rapidly gaining prominence as treatment processes that produce good quality effluents that are low in concentration of dissolved organic compounds such as dyes. The process of adsorption has an edge over the other methods due to its sludge free clean operation and completely removed dyes even from the diluted solution (Malik, 2003). Activated carbon (powdered or granular) is extensively used as an adsorbent due to its high level of effectiveness and has excellent adsorption efficiency for the organic compound, extended surface area, micro porous structure, high capacity and high degree of reactivity. However, commercially available activated carbons are very expensive (Malik, 2003). This has led many researchers to search for inexpensive and locally available adsorbents so that the process can become economically feasible.A wide variety of low cost material such as Wool Fiber and Cotton Fiber, Banana pith (Namasivayam, and Kanchana, 1993; Namasivayam, et al., 1993), Biogas residual slurry (Namasivayam and Yamuna, 1992a,b), Carbonized coir pith (Namasivayam, et al, 2001a,b), Coir pith (Namasivayam. and Kavitha, 2002), Hardwood (Asfour, et al, 1985), Mahogany sawdust, rice husk (Namasivayam, et al, 1992b), Parthenium hysterophorus (Rajeshwarisivaraj and Subburam, 2002), Neem (*AzadirachtaIndica*) husk (Alau, et al, 2010), Rice husk (Singh and Srivastava, 2001), Silk cotton hull, coconut tree sawdust (Kadirvelu, et al, 2003), Gypsum (Rauf, et al, 2009), Tamarind Fruit Shell (Saha, 2010) are used as low cost alternatives to activated carbon. The development of low cost alternative adsorbent has been the focus of recent research.

Here, the use of banana leaves ash as an adsorbent for the removal of a basic dye, Methylene Blue, is proposed. Banana leaf is a naturally occurring substance which is locally available in plenty of Bangladesh; when it is burnt to a suitable temperature, turns into ashes. Therefore, this study focuses on exploring the potential adsorbent from banana leaves ash for the removal of colorfrom aqueous solution of Methylene Blue dye through adsorption batch studies. Therefore, the main aim of the study is to find the influence of different parameters; such as shaking time, shaking speed, pH of solution, incubation temperature and centrifuging time on adsorption for color removal from MB dye solution.

2. METHODOLOGY

2.1 Material Collection and Preparation of Adsorbent

A lot of agricultural products and byproducts are producing throughout the year abundantly in Bangladesh. In this study, locally available Banana leaves are collected from locality of Rajshahi city, Bangladesh. The collected banana leaves are completely dried under the sun shine and burnt to obtain ash in present of oxygen. The powdered banana leaves ash is sieved through sieve no. 200 to get the desired particle size in between 0.053-0.075 mm of adsorbent. The sample is stored in air tight container. Physical characteristics of banana leaf and its ash are presented in Table 1.

Table 1: Characteristics of banana leaf and its ash

Ash content of leaf (%)	**Bulk density (g/cm^3)**	**Dry density (g/cm^3)**	**Moisture content (%)**	**Particle size (mm)**
5.13	0.303	0.282	7.41	0.053-0.075

2.2 Preparation of Dye Solution

Methylene blue was purchased from scientific store, Rajshahi, Bangladesh. An accurately measured quantity (10 mg) of dye was dissolved in 1000 ml distilled water to prepare the solution for experimental analysis. The stock solution of dye is preserved in refrigerator below the temperature of 4^oC for conducting the laboratory scale treatment experiment.

2.3 Experimental Design

Five important process parameters shaking time, shaking speed, pH, incubation temperature and centrifuging time were selected from literature which could influence the removal of color from aqueous solution through adsorption process. Methylene Blue aqueous solution of 100 ml was taken in a beaker and required adsorbent dose of 16 mg was added with the solution according to Bari and Sultana (2016). The varying pH level was adjusted by using HCl and NaOH solution. Colour removal efficiency from aqueous solution of methylene blue is expressed in terms of percentage. All experiments were conducted in triplicate and average was taken. The experimental design is shown in Table 2.

Table 2: Experimental design

Parameters	Variation	Fixed parameters
Shaking time (min)	15, 30, 45, 60, 75, 90, 105, 120, 135 and 150.	Shaking speed: 200 rpm; Temp: 30 ºC; p^H= 6.30
Shaking speed (rpm)	150, 200, 250, 300 and 350.	Shaking time: 3 hours; p^H= 6.30, Temp: 30 ºC
P^H	5.30, 6.30, 7.30, 8.30 and 9.30	Shaking speed: 200 rpm; Shaking time: 3 hours; Temp: 30 ºC
Incubation temperature (ºC)	20, 30,40, 50 and 60	Shaking speed: 200 rpm; Shaking time: 3 hours; p^H= 6.30
Centrifuging time (min)	3, 6, 9, 12 and 15	Shaking speed: 200 rpm; Shaking time: 3 hours; p^H= 6.30; Temp: 30 ºC

3. RESULTS AND DISCUSSION

The experiment for the color removal from aqueous solution, Methylene blue is carried out following batch adsorption process with five different varying parameters of shaking time, shaking speed, P^H, incubation temperature and centrifuging time. The absorbent dose is kept constant as 16 mg/100 ml of solution. The highest efficient parameter is selected from the batch experiment. The experimental results are presented and discussed in following sections.

3.1 Effect of Shaking Time

The shaking time of adsorbent with colored aqueous solution is one of the important parameters for the removal of color. Orbital rotary shaker was used to facilitate the intimate contact of adsorbent with dye solution. The contact time was varied at ten levels from 15 minutes to 150 minutes. The adsorbent dose was used of 16 mg/100 ml and shaking speed was maintained at 200 rpm. The experiment was carried out at natural solution of pH measured at 6.30. The results are presented in Figure 1.

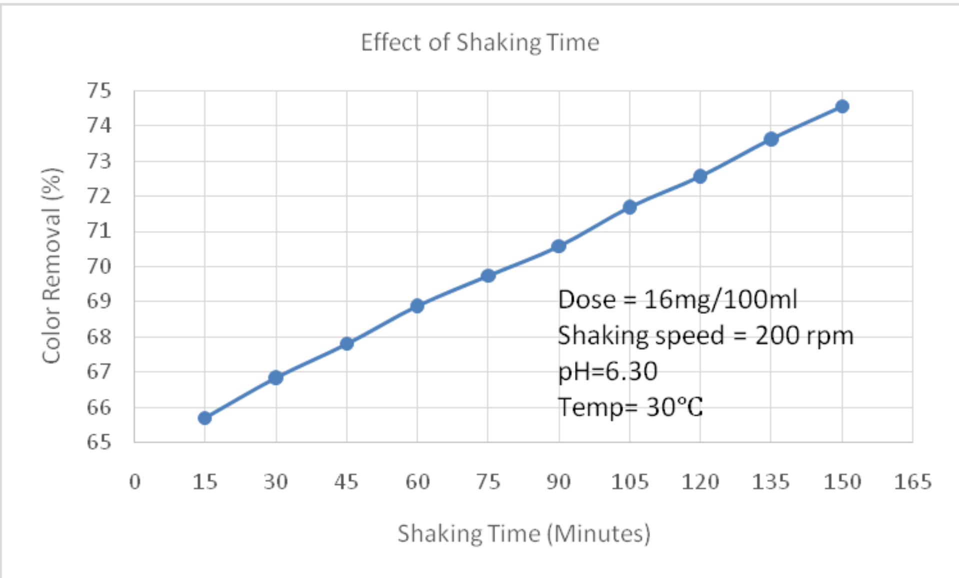

Figure 1: Effect of shaking time on removal of color from aqueous solution

The Figure 1 shows that the color removal efficiency is gradually increasing with the increase of shaking time. It can be said that the active surfaces of adsorbent are coming in intimate contact with the color particles those are gradually adsorbed on the surface. However, the removal was not reached to the equilibrium state within the experimental duration. It is evident that more contact time is required to reach in equilibrium. Moreover, though the experiment was not reached to the equilibrium, it is clear from the result that shaking time plays an important role in color removal.

3.2 Effect of Shaking Speed

Shaking speed is very important factor for influencing adsorption or de-adsorption of dye particle with adsorbent. The shaking speed is one of the mass transfer parameter in the bio-sorption phenomenon, influencing the distribution of the solute in the bulk solution and formation of the external boundary film (Khodaie, et al., 2013; Farah and El-Gendy, 2013). The speed was varied from 150 rpm to 350 rpm at five levels. The average results are presented by plotting in Figure 2. The removal of color increases with the increase of mixing speed and the highest removal of about 87.66% was found at 350 rpm speed.

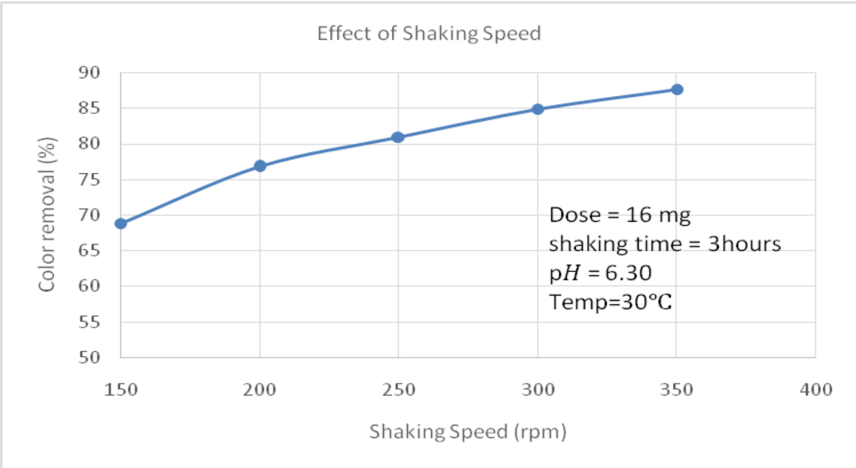

Figure 2: Effect of shaking speed on removal of color from aqueous solution

3.3 Effect of pH

The pH is the most important factor affecting the adsorption process. The actual pH of the solution was recorded as 6.30. The pH was varied from 5.30 to 9.30 with five levels set for this experiment. The obtained results of color removal are presented in Figure 3. The removal of color was induced with lowering of pH and increased with rising of pH from 6.3. The color removal was obtained of 65.50% at pH of 5.30 and the highest of 80.67% at pH of 9.30.

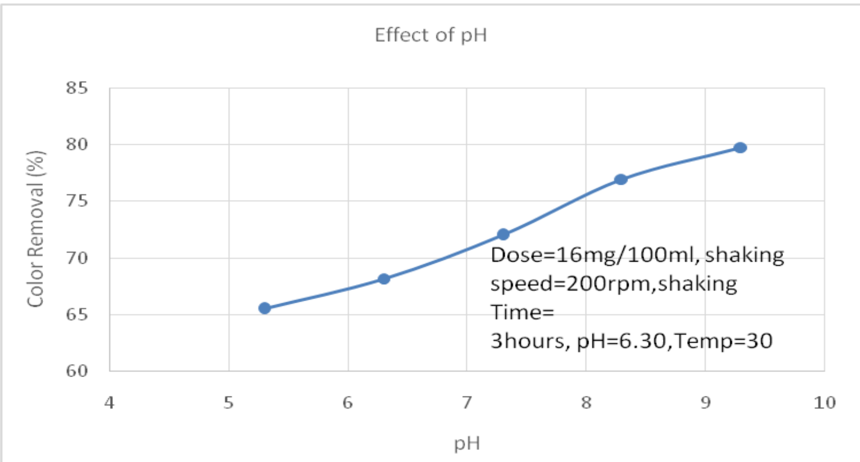

Figure 3: Effect of pH on removal of color from aqueous solution

3.4 Effect of Incubation Temperature

To observe any of variation of temperature on removal efficiency of color with locally available selected adsorbent, aqueous dye solution with adsorbent was incubated at varying temperature of 20℃, 30℃, 40℃, 50℃ and 60℃. The effect of variation of incubation temperature is presented in Figure 4. It was observed from the experiment that the removal of color decreased with the increase of incubation temperature.

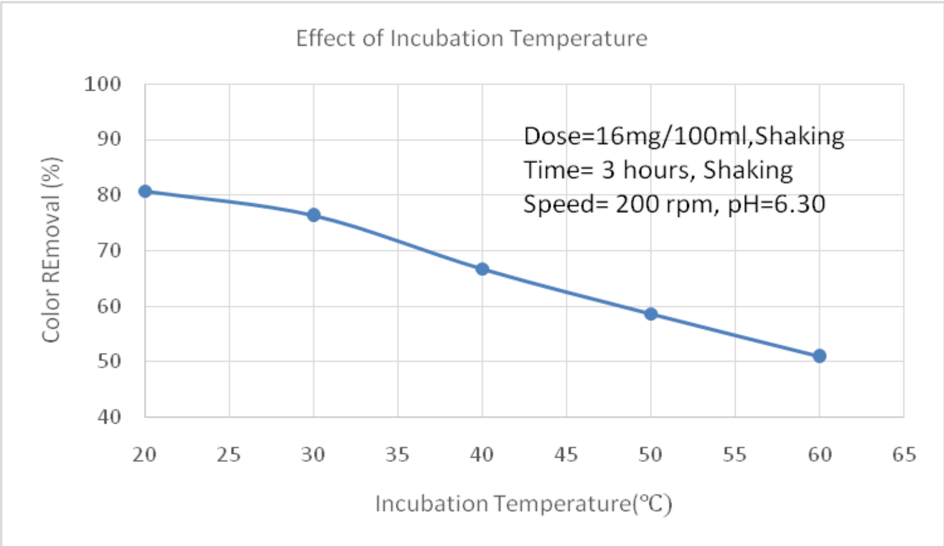

Figure 4: Effect of incubation temperature on removal of color from aqueous solution

3.5 Effect of Centrifuging Time

Centrifuging was used to separate the solid and liquid phase from aqueous solution methylene blue with adsorbent in order to determine the percentage of color removal from aqueous solution. The effects of centrifuging time on the removal of dyes are illustrated in Figure 5. From the experimental results, it can be seen that the percentage of color removal is increased with the centrifuging time. The color removal increased from 69.22% to 82.40% with 12 minutes of centrifuging at 9000 rpm. This indicates that the removal efficiency is higher as the centrifuging time is prolonged until equilibrium is reached. Moreover, color removal efficiency was reduced at 15 minutes of centrifuging time.

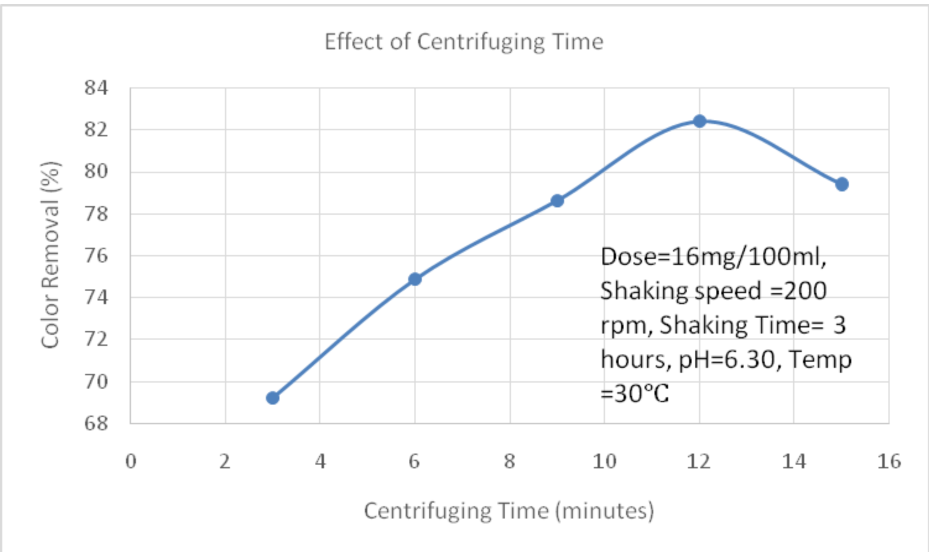

Figure 5: Effect of centrifuging time on removal of color from aqueous solution

4. CONCLUSIONS

Dying industries are producing huge quantity of effluent containing synthetic dye elements. Indiscriminately this colored wastewater is reaching to the environment and polluting the environment that becomes threat to the flora and fauna. Dye wastewater effluent is one of the major contributors to a variety of water pollution problems. Various measures and scientific techniques have been taken for the removal of dyes from wastewater. Adsorption technique has been used in this study and tried to develop a protocol for the removal of dye elements from the colored wastewater by using a locally available low-cost material banana leaves ash as adsorbent. Five parameters, shaking time, shaking speed, p^H, incubation temperature and centrifuging time were considered as the controlling factors. The highest color removal of 87.66% was achieved at shaking speed of 350 rpm for 3 hours, incubation temperature of 20°C, pH of 9.3 and centrifuging time of 12 minutes at 9000 rpm while particle size of banana leaves ash was maintained between 0.053-0.075 mm. Therefore, inexpensive and widely available banana leaves ash can be used as potential adsorbent for the removal of color from effluent discharges from dying and textile industry.

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