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Efficient removal of reactive dyes from industrial wastewater by peanut husk

Md. Abdul Khaleque[1], Shaikh Sayed Ahammed[2], Saquib Ahmad Khan[3], Md. Ekhtekharul Islam[4], Md. Shamim Alam[5]

[1,2,3,4,5] Department of Environmental Science, School of Environmental Science & Management, Independent University, Bangladesh.
Corresponding author;Md. Abdul Khaleque

Abstract: *A new bio-adsorbent to remove reactive dyes from industrial effluent was investigated in the present study. The adsorbent was the locally available peanut(Arachishypogaea)husk. Initially, sunfix red, a reactive dye common in textile effluents, was used to check the removal efficiency in terms of contact time, pH of dye solution and adsorbent dosage. 98% dye removal was achieved at adsorbent/dye ratio by mass of 2.5:1 at pH 7 in 150 minutes contact time. The adsorbent was also applied to deep colored, raw textile wastewater samples and it was found that 2.5 g of adsorbent was able to convert 100 mL of deep colored wastewater to transparent water at pH 7. Additionally, treatment by the adsorbent resulted in significant decreases in pH, BOD, COD, TS, TDS and TSS of wastewater, while improving DO level.*

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I. Introduction

The global yearly production of 10,000 types of commercially available textile dyes has reached approximately 7.10×10^5 metric tons [1]. It is estimated that 2-20% of such dyes are directly released in various environmental constituents as aqueous effluents [2]. The World Bank estimates that 20% of global industrial water pollution comes from the treatment and dyeing of textiles [3]. On average, the textile processing industry requires 50-150 liters of water per kg (L/kg) of textile material processed [4] which is in sharp contrast with the fact that in many regions of the world less than 10 L of water is available per person per day.

At present, primary, secondary, and tertiary methods are used worldwide to treat wastewaters. Primary treatment involves screening, sedimentation, flotation and flocculation to remove fibrous debris, insoluble chemicals and particulate matter [4]. Secondary stages are designed to eliminate the organic load and consist of a combination of physico- chemical separation and biological oxidation [4]. Both primary and secondary treatment cannot significantly remove colored materials. Tertiary stages of treatment have become more important but increase treatment costs. Some of these methods involve addition of more chemicals making the processes environmentally unfriendly [5]. Industry owners do not show interest to install these methods due to high running costs and maintenance problems [6]. Ultimately, in many developing countries particularly in India, China, and Bangladesh, the untreated dye-enriched textile wastewaters are discharged directly into various water bodies contributing to environmental degradation, loss of aquatic lives, and harmful human health impacts [7].

In recent years, the uses of natural adsorbents have gained a remarkable importance due to their low cost, environmental friendliness, local availability, and sustainability [8]. In previous studies Khalequeet al. (2017 & 2018) found that locally available hogla (Typha angustata) leafand aman rice(Oryza sativa) husk can remove sunfix yellow reactive dyes from textile wastewater efficiently [9,10].

In this study peanut (Arachishypogaea)husk was tested as an adsorbent to remove reactive dyes. Peanut husk possesses granular structure, high chemical stability and high porosity which are very important characteristics for an efficient adsorbent [11]. The peanut huskadsorbent is indigenous, renewable, cost-effective and environmentally friendly.

II. Material And Methods

Materials

The raw peanutwas collected from local sources. Sunfixred reactive textile dye was collected from a local textile manufacturing company.

Methods

Fresh peanut husk was separated from peanut.The husk was sun dried, ground in a blender (Philips, HR2118) and sieved with plastic sieve. The sieved husk was washed with 500 mL of distilled water twice and filtered. It was stirred in 500 mL of 0.5% of acetic acid at 60°C for 90 minutes and filtered again. Finally, the residual husk was dried at 105°C for 24 hours. For drawing the calibration curve, a stock solution of sunfix red dye was prepared by dissolving 0.1 g of dye in de-ionized water in a 1 L volumetric flask. The stock was then diluted to 5, 10, 15, 20, 25 and 30 mg/L solutions by adding de-ionized water. These standard solutions were scanned with a UV-Visible spectrophotometer (DR/4000U, HACH) and the λ_{max} of the dye was obtained at 570 nm. The results were used to draw calibration curve.

For the interaction of the adsorbent and dye solution, a specified amount of peanut husk and sunfixred dye solution were taken in a beaker and stirred using a magnetic stirrer for a specified time. Then the adsorbent was separated from the aqueous phase by filtration. The dye concentration in the filtrate was measured at 570 nm by the UV- Visible spectrophotometer.

III. Results And Discussion

Calibration curve for sunfix red dye

A calibration curve (Figure 1) was drawn using the standard solutions of the dye and measuring their absorbance at 570 nm. Concentration of dye solutions used varied from 5-25 mg/L.

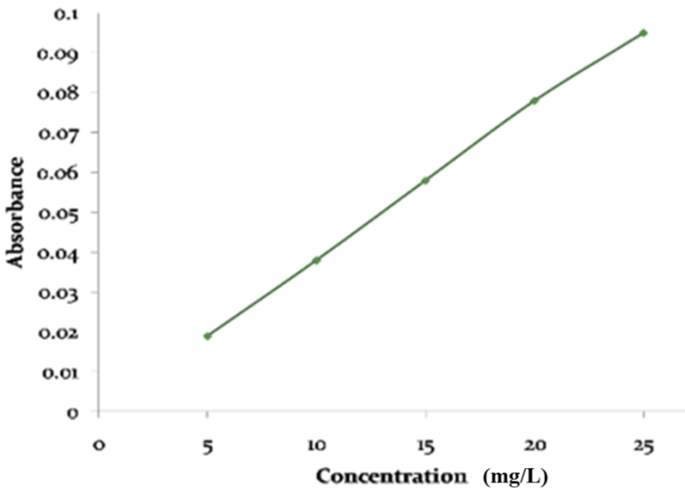

Figure 1: Calibration curve for sunfixred reactive dye

Interaction of sunfix red dye with adsorbent and calculation of removal efficiency

In a typical experiment 2.5 g of peanut husk was interacted with 100 mL of 10 g/L dye solution of specified concentration. The dye concentration was determined from the calibration curve using the absorbance obtained. The removal efficiency of dye was calculated by using the formula:

Removal Efficiency (%) $= \frac{C_0 - C_e}{C_0} \times 100$

Where,

C_0= initial concentration of dye solution

Ce= final concentration of dye solution

Effect of adsorbent dosage on adsorption

Effect of amount of adsorbent was studied to find out adsorbent/dye ratio that can result in quantitative adsorption with complete removal of dye from aqueous phase. The dosage of the adsorbent tested ranged from 0.5 to 4 g,added to 100 mL of 10 g/L dye solutions. Peanut husk showsalmost quantitative adsorption (98% removal efficiency) at adsorbent/dye ratio by mass of 2.5:1 (Figure 2).

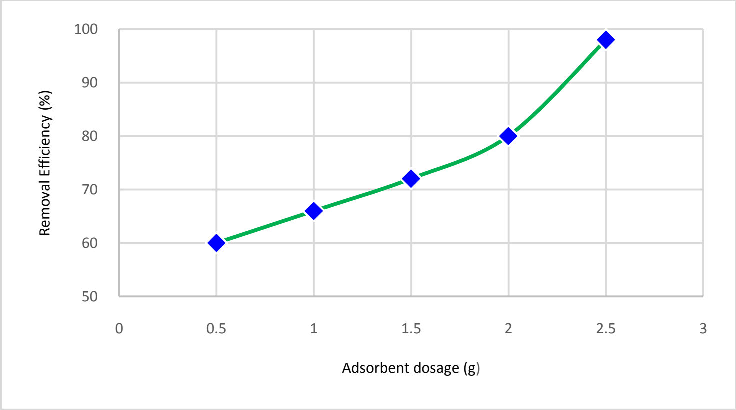

Figure 2: Effect of adsorbent dosage

Effect of pH on adsorption

Adsorption of sunfixred on peanut husk was observed in pH range 4-12. In acid medium bridging group present in dye is destabilized [12], therefore removal efficiency increases with pH, reaching maximum efficiency (98%) at pH 7 (Figure3). After pH 8, removal efficiency decreased significantly, with only 87% at pH 10.

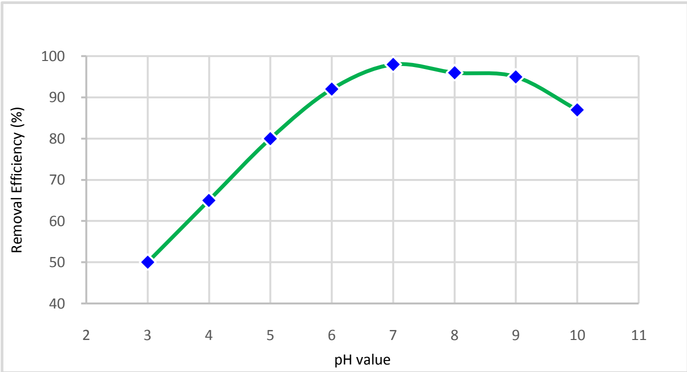

Figure 3: Effect of pH on adsorption

Effect of initial dye concentration on adsorption

Effect of initial sunfixred reactive dye concentration on adsorption on peanut husk was observed ranging from dye concentrations 5-25 mg/L (Figure 4), while other parameters remained constant. As initial dye concentration increased,adsorption capacity decreased because with increasing concentration, number of dye molecules increases in aqueous phase leading to lower removal efficiency.

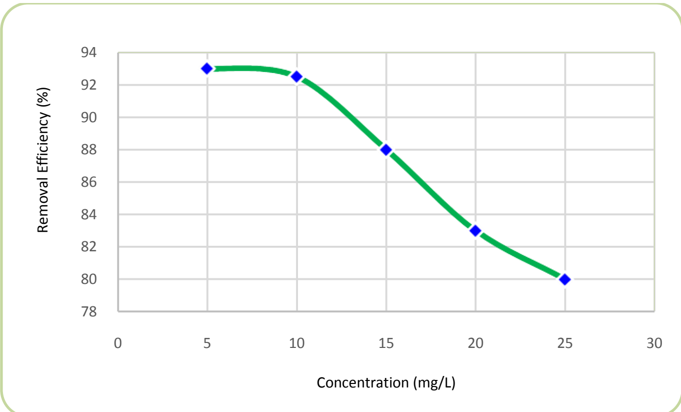

Figure 4: Effect of dye concentration

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Effect of contact time on adsorption

Effect of contact time for adsorption of sunfixred on peanut husk was studied up to 210 min while all other parameters remained constant. Observed removal efficiency is shown in Figure 5. Removal efficiency increases with time and reaches maximum 98% in 150 mins.

At 98% efficiency, it is considered that surface of the adsorbent becomes saturated. After that removal efficiency gradually decreases which could be due to desorption of dye molecules from surface of adsorbent.

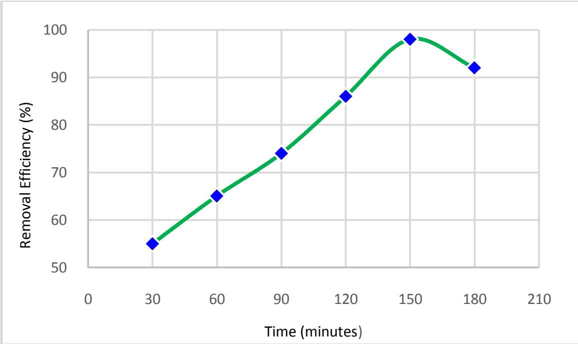

Figure 5: Effect of contact time

Interaction of the adsorbent with the raw wastewater

Before interacting with the adsorbent, the raw waste water, collected from a leading textile manufacturer in Bangladesh, was characterized by measuring pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total solids (TS), total dissolved solids (TDS), and total suspended solids (TSS). After the baseline values for these parameters are established the wastewater was treated with the peanut husk adsorbent. The values before and after treatment are presented in table no 1:

Table no 1: Characteristics of raw textile wastewater before and after treatment.

Parameters	**Before treatment**	**After treatment**
pH	11	7
Dissolved Oxygen (mg/L)	6.8	7.2
Biological Oxygen Demand (mg/L)	98	45.4
Chemical Oxygen Demand (mg/L)	992	385
Total Solids (mg/L)	3444	2210
Total Dissolved Solids (mg/L)	3224	2080
Total Suspended Solids (mg/L)	220	125

After interaction with the peanut husk adsorbent,pH of wastewater decreased from 11 to 7 because of the adjustment made to gain the optimum obtained pH for this adsorption system. DO level was found to increase approximately 6% after interaction. Significant decreases in BOD (54%) and COD (62%) was observed after treatment as well. The TS, TDS and TSS decreased by 36%, 35.5%, 43.5% respectively due to adsorption. Visual evaluation confirmed that after treating with the adsorbent, the color of the wastewater was completely removed, proving that the adsorbent can remove reactive dyes from wastewater. (Figure 6)

A: Before treatment B: After treatment

Figure 6: Textile wastewater before and aftertreatment

IV. Conclusion

In this research a new biomaterial peanut husk is found to be effective in removing reactive dyes from wastewater. Initially although a single reactive dye sunfixred was used, it is found that the adsorbent can remove other reactive dyes present in wastewater samples as well. Adsorption experiments carried out are affected by pH of dye solution, contact time and adsorbent/dye ratio. Neutral pH (i.e. 7) favors adsorption process. The highestquantitative adsorption (98%) is achieved at 150 minutes contact time. The adsorption dye ratio by mass of 2.5:1 is ideal for the present system to achieve 98% dye removal. Treatment by the adsorbent is found tolower the pH, COD, BOD, TS, TDS and TSS values, while increasing DO level of textile effluent. Therefore, the study concludes that peanut husk is a very efficient bio-adsorbent for removing reactive dyes from the aqueous phase and can significantly improve physical parameters of textile wastewater before discharge.

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