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UTILIZING AMAN HUSK FOR EFFICIENT REMOVAL OF REACTIVE DYES FROM INDUSTRIAL WASTEWATER

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ABSTRACT A new bio-adsorbent to remove reactive dyes from industrial effluent was investigated in the present study. The adsorbent was thelocally availableaman rice husk (*Oryza sativa).* Initially, sunfix yellow, 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. Complete removal (100%) of dye was achieved at adsorbent/dye ratio of 1450:1 at pH 8 with 125 minutes contact time. Then, the adsorbent was applied to deep colored, raw textile wastewater samples and it was found that 1.45g of adsorbent was able to convert 100 mL of deep colored wastewater to transparent water at pH 8. Additionally, treatment by the adsorbent resulted in significant decreases in pH, BOD, COD, TS, TDS and TSS of wastewater, while improving the DO level.

KEYWORDS : Bio-adsorbent,sunfix yellow, reactive dye, industrialwastewater,aman rice husk.

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 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]. Khalequeet al. (2017) found that locally available hogla leaf can remove sunfix yellow reactive dyes from textile wastewater efficiently [9].

In this study aman rice husk is tested as an adsorbent to remove reactive dyes. It possesses granular structure, high chemical stability and high porosity which are very important characteristics for an efficient adsorbent [10]. The aman rice husk adsorbent is indigenous, renewable, cost-effective and environmentally friendly.

MATERIALS AND METHODS

Materials

The raw aman rice husk was collected fromlocal sources.Sunfix yellow reactive textile dye was collected form Anwara Knit Composite Ltd., Mawna, Gazipur – a local textile and garments manufacturing company.

Methods

Fresh aman rice husk separated from rice grains was collected from a household source in Barisal district of Bangladesh. It 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 and adsorbent was prepared.For drawing the calibration curve, a stock solution of sunfix yellow dye was prepared by dissolving 0.1 g of dye in de-ionized water in a 1 L volumetric flask. The stock solution was then diluted to 5, 10, 15, 20, and 25 mg/L by adding de-ionized water. These standard solutions were scanned in the range 190-1000 nm with a UV-Visible spectrophotometer (DR/4000U, HACH) and the λ_{max} of the dye was obtained at 510 nm. The results were used to plot a calibration curve.

For the interaction of the adsorbent and dye solution, a specified amount of aman rice husk and sunfix dye solution was taken in a beaker and stirred using a magnetic stirrer for a specified time. Afterwards that the adsorbent was separated from the aqueous phase by filtration. The dye concentration in the filtrate was measured at 510 nm λ_{max} by the UV-Visible spectrophotometer.

RESULTS AND DISCUSSION

Calibration curve for sunfix yellow dye

A calibration curve (Figure 1) was drawn using the standard solutions of the dye and measuring their absorbance at 510 nm, λ_{max} of the dye. Concentration of dye solutions varied from 5-25mg/L.

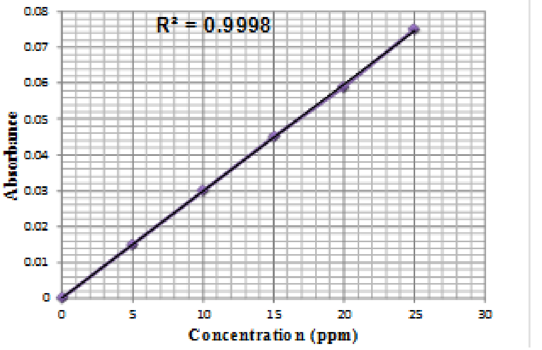

Figure 1: Calibration curve for sunfix yellow reactive dye

Using values obtained to plot an absorbance vs. concentration graph, a straight line passing through origin is obtained, satisfying Beer-Lambert law. The correlation coefficient (R^2) is found to be 0.9998 which proves the statistical validity of measurements. Therefore, the curve was used for determining unknown concentration for measured absorbances when required.

Interaction of sunfix yellow dye with adsorbents and calculation of removal efficiency

In a typical experiment 1.45 g of aman rice husk was interacted with 100 mL 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

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

Where,

C_0= initial concentration of dye solution, mg/L

Ce= final concentration of dye solution, mg/L

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(per addition), added to dye solutions of fixed volume and concentration. Aman rice husk shows quantitative adsorption (100 % removal efficiency) at adsorbent/dye ratio of 1450:1 (Figure 2).

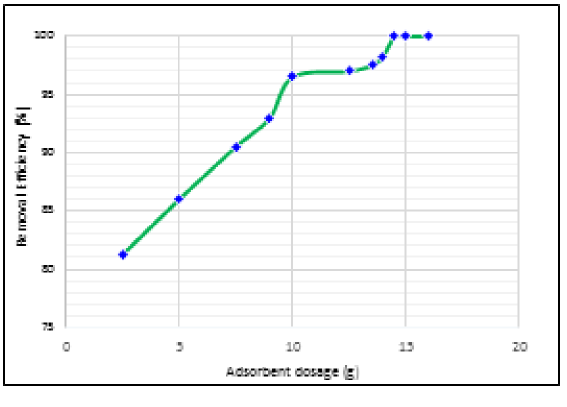

Figure 2: Effect of adsorbent dosage

Effect of pH on adsorption

Adsorption of sunfix yellow onaman rice husk was observed in pH range 4-10. In acid medium bridging group present in dye is destabilized[11]., therefore removal efficiency increases with pH and reaching maximum (96%) at around pH 8 (Figure3). After pH 8, removal efficiency decreased significantly, with only 87% at pH 10.

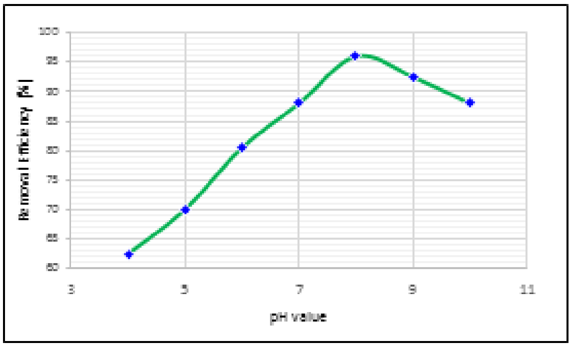

Figure 3: Effect of pH on adsorption

Effect of initial dye concentration on adsorption

Effect of initial sunfix yellow reactive dye concentration on adsorption on aman rice husk was observed as shown in Figure 4. Contact time and adsorbent concentration used were 125 min and 10g/L. 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.

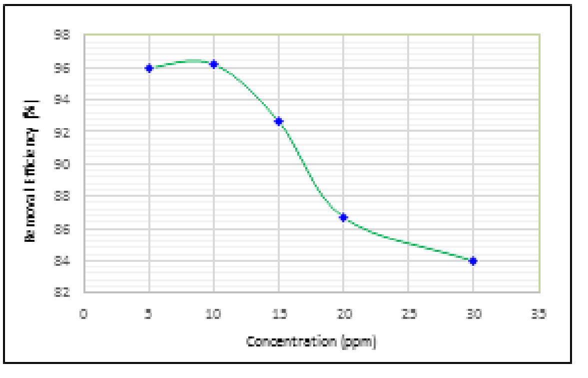

Figure 4: Effect of dye concentration

Effect of contact time on adsorption

Effect of contact time for adsorption of sunfix yellow on aman rice husk was studied for a period ranging from 30-180 min while all other parameters remained constant. Observed removal efficiency is shown in Figure 5. Removal efficiency gradually increases with time and reaches maximum (about 96%) in 125 mins.

At 96% efficiency, it is considered that surface of the adsorbent becomes saturated. After that removal efficiency gradually decreases which could be due to possible desorption of dye molecules from surface of adsorbent.

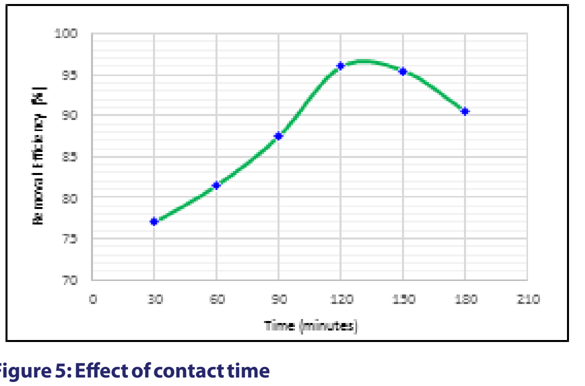

Figure 5: Effect of contact time

Interaction of the adsorbent with the raw wastewater

Raw wastewater samples were collected from a leading textile manufacturer Anwara Knit Composite, Mawna, Gazipur and brought to Environmental Science Laboratory, Independent

University, Bangladesh and preserved in refrigerator at 4°C. The following parameters were tested to characterize the preserved sample: 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 can interact with the aman rice husk adsorbent. The values before and after treatment are presented in **table 1:**

TABLE -1 CHARACTERISTICS OF RAW TEXTILE WASTEWATER BEFORE AND AFTER TREATMENT.

Parameter	Values	
	Before treatment	After treatment
Ph	12.6	8
Dissolved Oxygen (mg/L)	6.08	8.38
Biological Oxygen Demand (mg/L)	43.2	31.3
Chemical Oxygen Demand (mg/L)	768	332
Total Solids (mg/L)	3604	2674
Total Dissolved Solids (mg/L)	3110	2218
Total Suspended Solids (mg/L)	494	456

After interaction with the aman rice husk adsorbent,pH of wastewater decreased from 12.6 to 8. This is because of the adjustment made to gain the optimum obtained pH for this adsorption system. DO level is found to increase approximately 40% after interaction. Significant decreases in BOD (30%) and COD (60%) is observed after treatment as well. The TS, TDS and TSS decreases by 25%, 30%, 8% respectively due to adsorption. Visual evaluation confirms that after treating with the adsorbent, the color of the wastewater was completely removed proving that the adsorbent is capable remove reactive dyes from wastewater. (Figure 6)

Figure 6: Textile wastewater before and after treatment

CONCLUSIONS

In this research a new biomaterialaman rice husk was found to be very effective in removing reactive dyes from wastewater. Initially although a single reactive dye sunfix yellow 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. Highly alkaline pH favors adsorption process with peak removal efficiency (96%) at pH 8. Peak quantitative adsorption (96%) is achieved at a reasonable pace of 125 minutes contact time. The adsorption dye ratio of 1450:1 is ideal for the present system to achieve 100% dye removal. Treatment by the adsorbent is found to decrease the pH, COD, BOD, TS, TDS and TSS while increasing DO level of industrial effluent. Therefore, the study concludes that aman rice 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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