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Studies on Adsorption Efficiency and Kinetics of Dye Removal from Textile Effluent using some Natural Bio-adsorbent

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Abstract

Biosorption has emerged as a new technology compared to classical method like chemical precipitation for removing dye from aqueous solution. The adsorption efficiency was investigated of some natural bio-adsorbents which were Neem leaf (Azadirectaindica) & Mehagoni leaf (Switeniamahagoni) as powder form for the removal of dyes from textile effluents. Adsorption performance has been investigated using batch experiments. It is found that dye adsorption capacity (pollutant removal efficiency) of a steady system depends on adsorbent material, pH of solution, adsorbent dose, and contact time. It has been shown that when the adsorbent dosage increased from 0.5 to 2g the removal of the dye varied from 11 % to 77 % and at pH 2 efficiency was observed in case of Neem leaf for Orange MERL by 65%, Blue BFG by 50%, Red EV8V5 by 90% and in case of Mehagoni leaf for Orange MERL by 53.1%, Blue BFG by 67.7%, Red EV8V5 by 77% respectively. Spectrophotometry was used to measure the concentration of the dyes. The removal efficiency of Neem leaf (Azadirectaindica) was found for Orange MERL by 66.02%, Blue BFG by 50.5%, Red EV8V5(dye) by 57%, and with Mahagoni leaf (Switeniamahagoni) for Orange MERL by 60%, Blue BFG by 67.77%, Red EV8V5(dye) by 77%. Significant removal efficiency was shown for bio-adsorbents which were used throughout the work so these adsorbents could be used in industries in the treatment of textile effluent.

Key words: Effluent, textile, quality parameters, adsorption, bio-adsorbents, spectrophotometry.

1. Introduction

Water pollution mostly comes from wastewater which contains industrial and environmental pollutants. Dyes manufacturing causes serious problems for waste-waters. They affect biodegradation, light penetration and photosynthesis. Minor releases of colorants impact the aesthetics and health disorders to organisms exposed to them producing imbalances in these ecosystems [**1**], [**2**]. Furthermore, some of these dyes on passage to drinking water cause damage to human life [**18**]. For example orange MERL, red dye (Red EV8V5) & reactive turquoise (blue BFG) usually used to dye cotton and wool, can cause serious health problems such as vomiting, hard breathing, and mental disorder [**3**].A huge number of industries including paper and pulp, printing, textile, tannery, metallurgical, electroplating, petroleum, paint, pharmaceuticals, food preserving, wood preserving, detergent use water and varioustypes of chemicals. The textile effluents are notoriously known to contain strong color, large amount of solid, highly fluctuating pH, Organic content and heavy metals [**4**]. Colored and heavy metals containing effluents are the significant source of environmental (especially, water) pollution from a number of industries, particularly textile in our country. A common ground for these pollutants is their mode of entry into the water system. Broadly speaking, water ways are subject to entry of pollutants by discharging pollutants into the river-water system directly, Reactions and transport across the air-water interface, reactions and transport across the water-sediment interface, run off and/or seepage with subsequent transport

It has become essential to treat the waste to a certain degree prior to its disposal. It is quite impossible to provide enough money to mitigate the problem due to these pollutions for a developing country like Bangladesh. So, the development of some cheapest and easiest methods is needed for our country. Traditional methods for the treatment of textile wastewater consist of biological, physical and chemical methods [**15**]. Because of large variability of the composition of textile wastewaters most of the traditional methods are becoming inadequate. Bio-sorption utilizes the ability of biological materials to accumulate heavy metals and dye from waste streams either by metabolically mediated or purely physico-chemicals pathways of uptake [**3**]. A wide range of non living biomass like bark, lignin, peanut hulls, leaf, as well as living biomass like fungi, bacteria, yeast, moss, aquatic plants, and algae has been used as bio-absorbents [**4**]. Bio-adsorbents are gaining considerable importance to treat heavy metals and dyes of the industrial effluents than any other technology. The potential advantages of bio-adsorbents over other conventional treatment methods are: (1) low cost, (2) high efficiency in the removal of heavy metals and colored materials from effluents, (3) no need to supply other chemicals, (4) regeneration of adsorbent (5) regeneration of waste substances**.**

The Neem tree (*Azadirectaindica*) and Mehagoni tree (*Switeniamahagoni*) are noted for their drought resistance. Normally they grow in areas with sub-arid to sub-humid conditions, with an annual rainfall between 400 and 1200 mm. They can grow in regions with an annual rainfall below 400 mm, but in such cases it depends largely on ground water levels. Neem&Mahagoni can grow in many different types of soil, but they thrive best on well drained deep and sandy soils. They are typical tropical to subtropical tree and exist at annual mean temperatures between 21-32°C. They can tolerate high to very high temperatures and does not tolerate temperature below 4°C **[14]**.

2. Experimental

Two significant analytical techniques were employed throughout the work, Spectrophotometric method &Physico-

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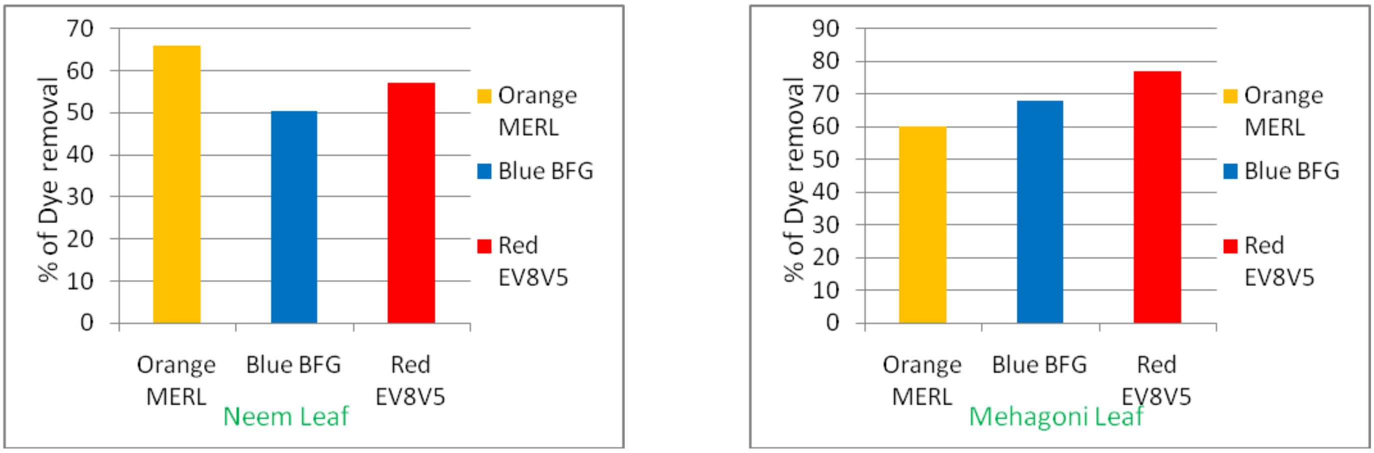
chemical adsorption process **[8], [9]**. Adsorption process was performed on an electric shacking machine until they achieve equilibrium state of absorption **[2], [9].** UV-visible spectrophotometric method was carried to get concentration by Beer-Lambert laws.

3. Efficiency of bio-adsorbents in the removal of dyes from standard solutions



Figures 1: Efficiency of bio-adsorbents in the removal of dyes

4. Effect of different parameter on adsorption

4.1. Effect of adsorbent dosage

The effect of adsorbent dosage for different dye adsorption onto Neem leaf &Mahagoni leaf is shown in table (5) & figure (6, 7).The adsorbent amount was taken between 0.5 g - 2 g and initial dye concentration was determined as 10 mg/L. The results show thatwhen the adsorbent dosage

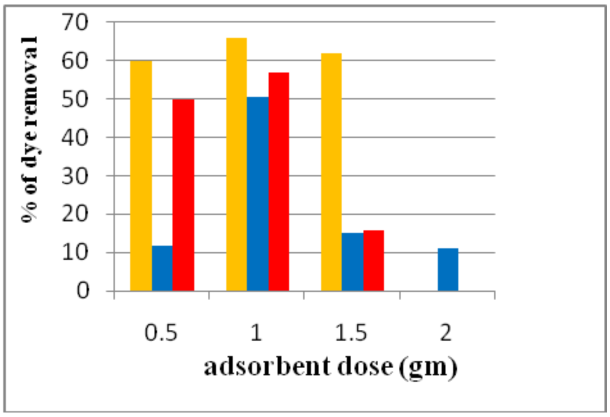


Fig 2: Effect of adsorbent dosage (Neem leaf)

4.2. Effect of initial pH on the adsorption of different dyes:

In general the pH of the solution affects the chargeof the dye and of the adsorbent. In my case it affectsboth the adsorbent & dye. The visiblespectrum of dyes does not change in function of pH.The effects of pHwere studied in range of pH

Adsorption efficiency of the bio-adsorbents in case of removal of dye from solution was measured. The percent removal of dye on the adsorbents was calculated from

$$\% \text{ removal} = \frac{C_0 - C}{C_0} \times 100$$

Where Co is the initial concentration and C is the final concentration of dye in ppm **[2]**.

increased from 0.5 to 2gthe removal of the dye varied from 11 % to 77 %, andthen reached an equilibrium state. As Pavan et al. reported **[15]**, thelarger adsorption surface causes higher adsorption of dye. Similar result is obtained with Neem leaf &Mehagoni leaf **[15]**. Therefore, for convenience theadsorbent dosage in the following experiments was selected as 1.0 g. The volume of dye solution in contactwith 1g of each adsorbent (neem leaf &mehagoni leaf) also has been defined. The experimental results show 100 mL of sample is enough **[14], [21]**.

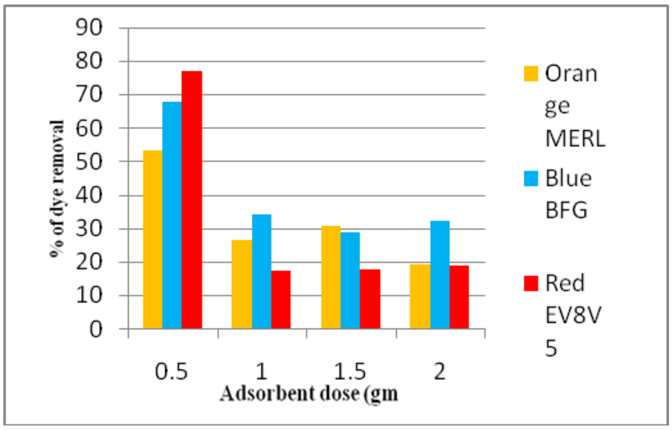


Fig 3: Effect of adsorbent dosage (Mehagoni leaf)

2 - 8. For adjustingpH, diluted solutions of NaOH and HCl were used. Inthis analysis, initial dye concentration was determined as 10 mg/L and experiment was carried out at room temperature (25°C) **[2], [14]**. Fig. (8 & 9) pointed out that at pH 2 the dyeremoval was maximum incase of both Neem&Mehagoni leaf and for pH 4 - 8, the dyeremoval remained almost similar. The highest adsorption at pH 2 is

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observed for Neem leaf Orange MERL 65%, Blue BFG 50%, Red EV8V5 90% and Mehagoni leaf Orange MERL 53.1%, Blue BFG 67.7%, Red EV8V5- 77% respectively.

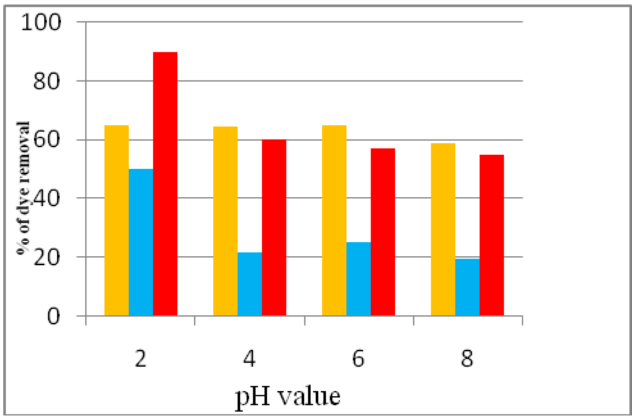

Fig 4: Adsorption by Neem leaf at diff. pH

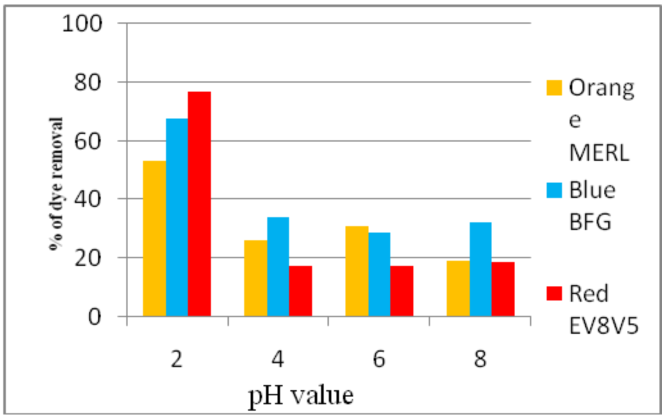

Fig 5: Adsorption by Mehagoni leaf at diff. pH

4.3. Effect of contact time

The effect of contact time for different dye adsorption onto different bio-adsorbent is shown in table 7 and Fig.10 & 11. It can be observed that the rate of adsorption was fast in the first 1.2 hr then gradually increases and then slow down as equilibrium is reached. This may be due to strong attractive forces between the dye molecules and the adsorbent. The results indicatedthat after 4 h the adsorption reached almost equilibrium forlow initialdye concentration. As the equilibrium timeis also function of initial dye concentration **[15]**, 6h is sufficient to reach equilibrium for isotherm adsorption study.

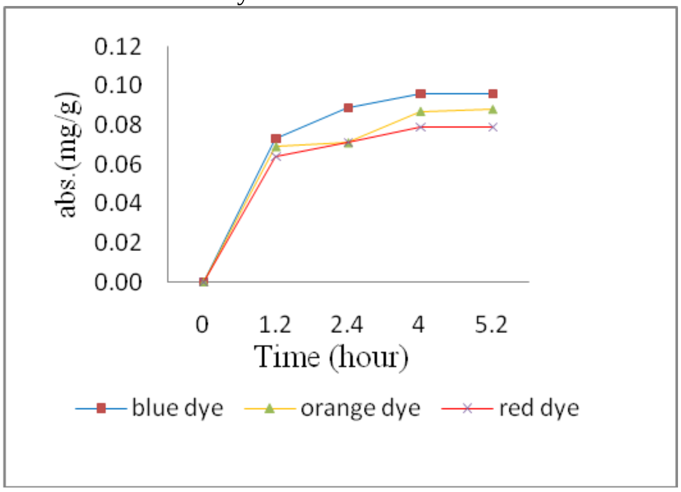

Fig 6: Abs. vs. time plot of different dye foradsorbent Mahagoni leaf.

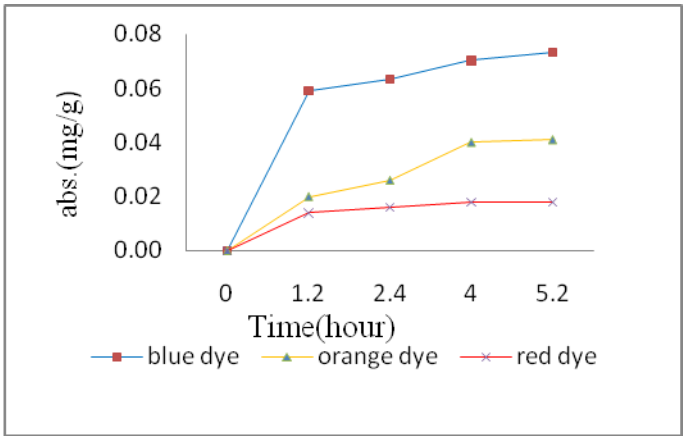

Fig 7: Abs. vs time plot of different dye for adsorbent neem leaf

5. Conclusion

In this study-the efficiency of the bio-adsorbents in case of removal of a typical dye from a standard dye solution was measured. The efficiency for Neem leaf (*Azadirectaindica*) was found Orange MERL 66.02%, Blue BFG 50.5%, Red EV8V5(dye) 57%, and for Mahagoni leaf (*Switeniamahagoni*) Orange MERL 60%, Blue BFG 67.77%, Red EV8V5(dye) 77% respectively. In case of adsorbent Neem leaf &Mehagoni leaf they showed good adsorption efficiency for dye Orange MERL, Red EV8V5, Blue BFG.

On the other hand this study was carried out to determine the effect of different parameter on efficiency like adsorbent dose effect, pH effect and contact time effect. Results show thatwhen the adsorbent dosage increased from 0.5 to 2gthe removal of the dye varied from 11 % to 77 %, andthen reached an equilibrium state. For some dye 0.5g of each adsorbent shows good adsorption efficiency (Orange MERL 60% for Neem& Red EV8V5 56% for Mahagoni), but maximum efficiency was fond for 1.0g except one Orange MERL for Mahagoni leaf which showed efficiency 74.48% with 2.0g of adsorbent. When pH of the sample solution varied from 2 – 8 adsorption efficiency was varied, maximum adsorptions was found at pH 2 (Neem leaf Orange MERL 65% ,Blue BFG 50%, Red EV8V5 90% and Mehagoni leaf Orange MERL 53.1%,Blue BFG 67.7%, Red EV8V5- 77% respectively).

When contact time was varied removal efficiency of bio-adsorbents also varied. It was found that the rate of adsorption was fast in the first 1.2 hr then gradually increases and then slows down as equilibrium is reached.

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