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Exploration of Environmental Friendly adsorbents for Treatment of Azo Dyes from Textile Wastewater and its dosage optimization

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ABSTRACT

The major industries contributing to water pollution is textile mills. In the present study, the synthetic waste water was treated by using red brick dust and alum. Its evaluation was done by measuring pH, EC, TDS and Color removal percentage. The experiment carried out with different concentration of red brick dust and alum to measure the dosage suitability of these adsorbents for dye color removal. The pH of synthetic dye was maintained at 4, 7 and 9 then passed through the red brick dust and alum. The sequential treatment, adsorption followed by coagulation was adopted to treat the wastewater. Dosage variability showed very significant results and 75% red brick dust with combination of 25% alum concentration was found favorable for color removal of dye. The material was capable of removing color up to 92% at pH 7 at normal temperature. Other parameters like EC and pH showed abnormal trends as the amount of alum was increased but TDS were tend to decreased with the increasing amount of alum. The experimental result showed that the material has good potential to remove color from effluent and good potential as an alternate low cost adsorbent. There are many physical and chemical treatment methods available for removal of color but all these methods have problems associated such as secondary effluent, hazardous and harmful end products, high energy consuming, non-economic etc. These problems can be overcome by the use of physical treatment method (adsorption and coagulation method) which is not hazardous for environment.

1. INTRODUCTION

Textile process contains wet and dry processes. The wet processes include scouring, singeing and dyeing which use a large amount of water. Among this process dyeing requires immense amount of water which involves changing the color of the textile spun (Wang et al., 2002).

Dyes are small molecules comprising two key components the functional group, which bonds the dye to the fiber and chromophore, responsible for the color (Waring and Hallas, 1990). Wastewater from dyeing units is frequently rich in color, containing residues of reactive dyes and chemicals like aerosols, complex components, high chroma, which possess high BOD and COD values and material hard to degrade. The harmful impacts of dyestuffs and other natural mixes, and in addition acidic and basic contaminants, from industrialization on the overall population are broadly acknowledged. The structure is more complex and stable, bringing about more trouble in degradation of coloring wastewater (Shaolan et al., 2010). Moreover, this wide range of dyes and various dyeing auxiliaries make textile wastewater hard to treat with a single treatment technique in all situations (Cooper, 1978). Dyes can be classified into different types depending on their chemical compositions and properties. Therefore, the usage of dyes varies from industry to industry depending on the fabrics they manufacture. The worldwide production of dyes is 700,000 to 1000,000 tons per year, which compatible to over 1×105 commercial products and azo dyes has 70% share to the dyes market (Pereira et al., 2012).

It is evaluated by the World Bank that 17 to 20% of water contamination originates from textile manufacturing industries under the dyeing and finishing process. There are seventy-two poisonous and health hazardous chemicals have been known in water from dyeing processes, and thirty of this cannot be removed (HSRC, 2005).

The wastewater has a great quantity of suspended solids, a strong coloration, a highly fluctuating pH, high temperatures and substantial quantities of heavy metals (Ni, Cr, Cu) and chlorinated organic compounds (Araujo and Yokoyama, 2006). Consequently, these dyes are unavoidably released in mills effluents. Azo dyes have a serious impact on environment, because their degradation products and precursors (such as aromatic amines) are extremely carcinogenic (Szymczyk et al., 2007).

It is expected to treat textile wastewater before the disposal in natural water system when it contains such noxious characteristics (Kabir *et al.,* 2002). The high concentration of COD, BOD, total dissolved solids, total suspended solids and pH bring down the oxygen concentration from water streams that can be ameliorate the anaerobic conditions and kill the aerobic organisms of water (Savin and Romen, 2008).

Effluent treatment methods can be classified into chemical, physical and biological methods. Single treatment method is insufficient to remove color so; there is not an exclusive treatment technique among these three methods of treatments to deal with the textile effluent. Dyes exhibits different behavior to different methods like dyes are not easy to biodegrade, certain acidic dyes are not easily absorbed by active sludge; hence they escape treatment and few particularly the hydrolyzed reactive. Various treatment methods can be combined to eliminate more than 85% of unwanted matter (Donnet and Papirer, 1912). Two mechanisms adsorption and ion exchange are involved in decolonization, and is affected by various factors including adsorbent's surface area, dye & adsorbent interaction, particle size, pH, contact time and temperature (Ruthven *et al.,* 1984). Surfactants and dyes with high molecular weights are easily removed by the coagulation processes followed by flotation, filtration and sedimentation respectively (Lee, 2000).

This research work was planned in order to explore environment friendly adsorbents to remove coloring due to azo dyes from textile wastewater. In this regard to investigate the performance efficiency of red brick dust in combination with coagulant (alum) as an adsorbent for treatment of azo dyes. To evaluate the changing patterns of different parameters like pH, EC, TSS, TDS and color intensity, after treatment.

1. Materials and methods

2.1 Research Methodology

A number of samples were prepared by dissolving 0.25g solute (azo dye) in 3 liters distilled water. These samples were passed through the red brick dust with different proportions of coagulant (alum). Red brick dust and coagulant (Alum) were taken in a pipe having a hole at bottom for extraction

of treated dye solution.

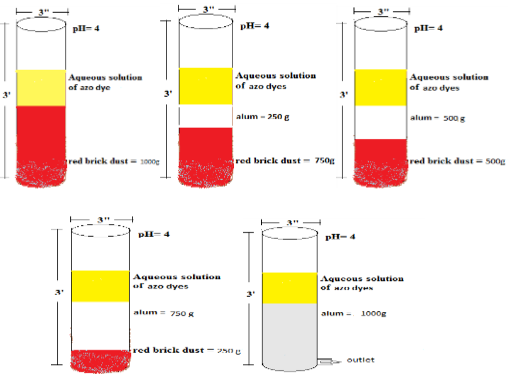

Fig 1: Different Proportion Combination of Red Brick Dust and Alum at pH 4

The same procedure was revised at pH7 and pH 9.

2.2 Experimental Methodology

First of all synthetic wastewater solution was prepared by adding 0.25 g of azo dyes in 3 liters of distilled water. Then shake it for 10 minutes at shaker with 5⁰c temperature and 5 rev to make a homogenous mixture. After that the pH of solution was maintained at 4, 7 and 9 by adding 0.1N Hcl acid and 0.01N NaOH base as original pH of azo dye solution was 5.54 before any interference. The prepared solution of different pH levels was treated by adsorption method. The experiment was repeated at different amounts of adsorbents (red brick dust + alum) in proportion of (1000g+0), (750g+250), (500g+500g), (250g+750) and (0+1000g) respectively. A fixed amount of adsorbent was placed into designed pipe and synthetic azo dyes solution was passed through it with retention time 3 hours. For each hour, sample was collected from the pipe outlet after treatment. So, for each pH level 3 samples were taken out from pipe after passing the solution from different amounts of adsorbents. Evaluation was done by measuring different parameters like pH, EC, TDS and color removal percentage of solutions before and after treatment.

3. Results and discussion

Results were analyzed and discussed by RCBD two (2) way factor factorial design with significance level 5%.

Table 1 Analysis of Variance for EC

Sources	DF	SS	MSS	F	P
Factors	2	1218283	609141		
HRS	2	324791	162395	0.57	0.5691 *
Treatments	5	3.615E+09	7.229E+08	2551.51	0.0000 **
HRS*Treatments	10	852662	85266.2	0.30	0.9760 ns
Error	34	9633478	283338		
Total	53	3.627E+09			

*** Significant; ** Highly Significant; ns Non-Significant**

Table 2 Analysis of Variance for pH

Source	DF	SS	MS	F	P
Factors	2	5.724	2.8618		
HRS	2	0.017	0.0087	0.01	0.9915ns
Treatments	5	150.760	30.1520	29.50	0.0000**
HRS*Treatments	10	0.168	0.0168	0.02	1.0000ns
Error	34	34.754	1.0222		
Total	53	191.423			

Table 3 Analysis of Variance for TDS

Source	DF	SS	MS	F	P
Factors	2	839086	419543		
HRS	2	7649721	3824861	21.30	0.000
Treatments	5	2.900E+08	5.800E+07	322.94	0.000
HRS*Treatments	10	1.679E+07	1678573	9.35	0.000
Error	34	6105993	179588		
Total	53	3.214E+08			

Table 4 Analysis of Variance for Color Removal Percentage

Source	DF	SS	MS	F	P
Factors	2	52.7	26.33		
HRS	2	4220.6	2110.31	60.68	0.0000**
Treatments	5	49956.9	9991.37	287.30	0.0000**
HRS*Treatments	10	3236.4	323.64	9.31	0.0000**
Error	34	1182.4	34.78		
Total	53	58649.0			

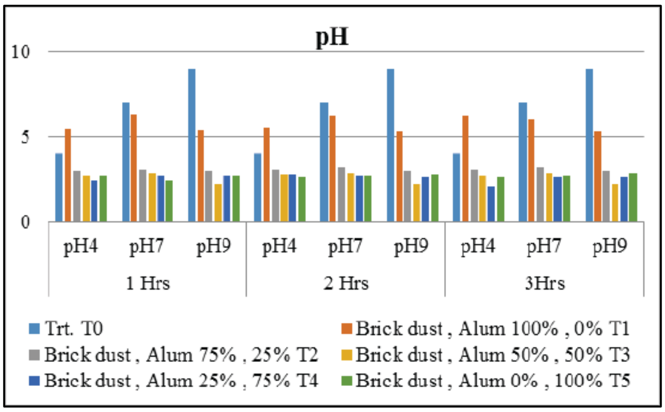

Fig. 3: Results of pH Variance

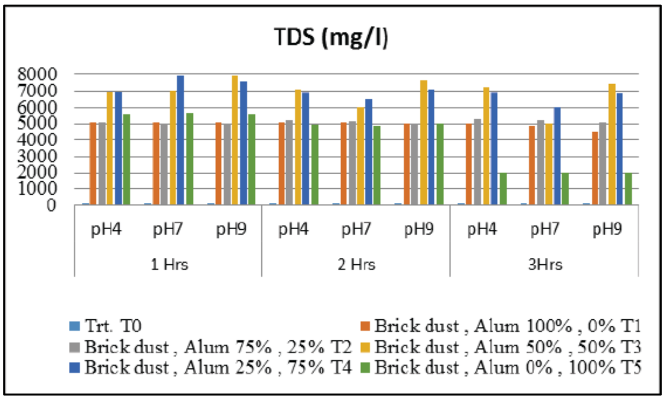

Fig. 4: Results of TDS (mg/L) for different treatments at pH 4, 7 and 9

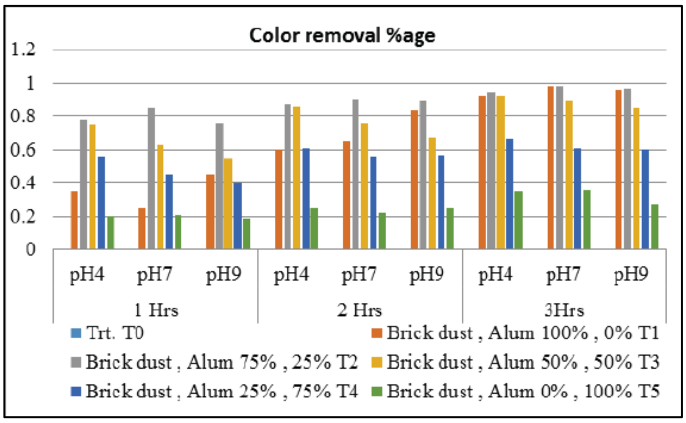

Fig 5: Results of Color Removal in percentage

4. Discussion

Experimental results showed that as the brick dust applied the results of EC increased from 170 µS/cm to 5020 µS/cm for pH4 however with the passage of time EC value reduced 4240 Unit. But with the usage of alum EC showed increasing pattern as the dosage of alum increased from 0% to 100% and highest value is19900µS/cm. For pH7 and pH 9 results are similar as the results of pH 4 expressed in Fig. 2. Values of EC for pH7 and pH 9 increased from 870 and 120 to 4550 and 4060 respectively.

In the case of pH, before treatment the value of pH is higher and after treatment the value of pH tends to decrease. Treatment with 100 % red brick dust the results increased on an average from 4 to 6 for all three pH (4, 7 and 9) no significant change with the hour of treatment. But with the usage of alum pH shows decreasing pattern as the dosage of alum increased from 0% to 100% pH of solution decreases tremendously up to 2.1. For pH4, pH7 and pH9 results are almost similar. Experimental results showed that the pH is inversely affected by the alum.

The results of analysis of variance for total dissolve solids for different treatments showed highly significant relations. The best treatment result is T_5 (0% red brick dust + 100% alum) at 3 hour. The graphical representation showed that the control treatment has lower value of TDS then the other treatment values. After treatment results showed that TDS are increased using high dosage of red brick dust with the combination of alum, as the dosage of red brick dust decreasing TDS are also decreasing.

Experimental results for color removal percentage showed that as the brick dust treatment applied the results increased from 20 % to 98%. With the passage of time value increased tremendously. But with usage of alum color removal percentage showed decreasing pattern as the dosage of alum increased from 0% to 100% and it showed lowest values with 100% usage of alum is 20%.

5. Conclusion and Recommendation

The results of present study show that red brick dust and alum have suitable adsorption capacity with regard to the removal of azo dye from its aqueous solution. Red brick dust is good adsorbent and the adsorption is highly dependent to contact time and pH of aqueous solution of azo dye. The optimal pH for favorable adsorption of azo dyes is 7. Sequential treatment of textile wastewater, adsorption followed by coagulation is good to remove color of dye. Results of EC, pH, TDS and Color removal percentage found better for dosage of 75 % red brick dust and 25 % alum as compare to other dosage. Red brick dust and alum do not perform well separately to treat wastewater, combination of both is efficient to remove color as well as solid contents.

It is recommended that sequential treatment adsorption followed by coagulation can also be reversed as coagulation followed by adsorption for the good results of EC and TDS. The studies is also to be continued on increasing the adsorption capacity of the red brick dust by treating it with other acids .it have to be further continued to find out if red brick dust can also be used for removal of other dyes. Conclusively, the expanding of red brick dust in field of adsorption science represents a viable and powerful tool, leading to the superior improvement of pollution control and environmental preservation.

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