International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 04, April-2015

Decolourization of Disperse Dye by Low-Cost Waste Adsorbent

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Abstract— **Flyash is the waste material from thermal power plant. This is produced in abundance globally and poses risk to health as well as environment. Thus their effective utilization has always been a challenge for scientific community. Hence, the study was performed to use the waste material i.e. flyash as a low cost adsorbent for decolourization of disperse dye from aqueous solution through column technique. Column experiments were carried out at equilibrium condition for different concentrations of disperse blue 354 ranging between (1-20) ppm, respectively. The column was packed using different combination of flyash and sand (1:1, 1:2 and 1:3). The removal of disperse dye from column experiments decrease with the increase in solution concentration at room temperature, showing the process is dependent on the initial concentration of the solution. The percentage removal of dye by adsorption was found to be 82% at lower concentration and 69% at higher concentration for disperse blue 354, respectively.**

Keywords— Flyash, Disperse Blue 354, Adsorption.

INTRODUCTION

In recent year, one of the major issue concerning environmental pollutants is industrial textile wastewater [1]. Dyes have toxic as well as carcinogenic, mutagenic effects on aquatic life and humans. Dyes are considered to be particularly dangerous organic compounds for the environment [2, 3]. The synthetic dyes can be classified as disperse dyes, reactive dyes, sulfur dyes, vat dyes, direct dye, acid dyes, and basic dye. Disperse dyes are nonionic dyes and widely used for dyeing of synthetic fibres, such as cellulose acetate, polyamide, polyesters, polyacrylonitries, and etc. The disperse dye which have low solubility in water can be treated as colloidal particles [4, 5]. The methods of color removal from industrial effluents include physical, chemical and biological methods [5-8]. Among these methods, adsorption appears to have considerable potential for the removal of color from industrial effluents. Various adsorbents have been tried for the removal of different types of synthetic dyes. Activated carbon is perhaps the most widely used adsorbent for the removal of many organic contaminants which are biologically resistant, but activated carbon is prohibitively costly [9-11]. Hence, it is necessary to find out a low cost adsorbent for treatment of the textile wastewater containing dye colour at tertiary level.

Flyash is the by-product producing during combustion of coal in the electricity generation process. Disposal of flyash has become an increasing economic and environmental burden. It has been already proved that flyash was very efficient for removing from Malachite green, Quinoline, reactive dyes, acid dye etc. [12].

In this work, the discoloration of disperse dye using flyash has been achieved through column technique and it was found that flyash could be a cheaper adsorbent for dye removal.

A. Material and Method

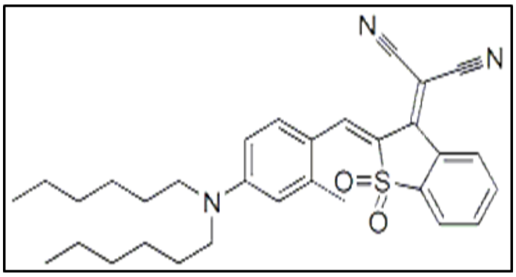
Flyash was procured from Koradi Thermal Power Plant, Nagpur, Maharashtra. It was washed several time with water to remove impurities. Then, it was dried in electric oven at 105^{O} C for 24 hr. The flyash was passed over the standard size mesh no.45 (354µ) molecular sieve (Endecotts.) The sand was also passed over standard size mesh no.14 (1.41mm). Dye was acquired from VAP CHEM, Surat, Gujrat. The chemicals used in the present study were of analytical grade.

A. I Chemical Characterization of Flyash

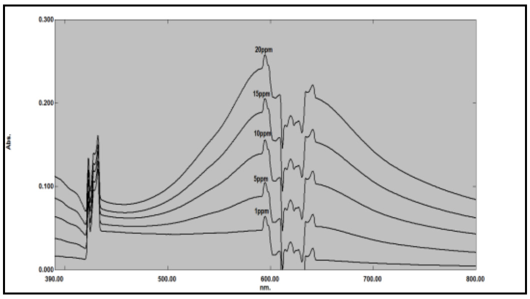
The chemical composition of fly ash was found to be: SiO_2 (60.36%), Al_2O_3 (23.69%), Fe_2O_3 (6.61%), CaO (0.77%), MgO (0.55%), MnO_2 (0.06%), MnO (0.30%) and L.O.I (0.24%). The surface area of flyash was measured through Brunauer-Emmett Teller (BET) (Micrometrics). The surface morphology and quality of flyash was characterized by a High Resolution Scanning Electron Microscopy (HR-SEM) (JEOL, JXA-840). The mineralogical compositions of flyash were measured using Desktop powder X-ray Diffractometer (XRD) (Rigaku).

A.II Adsorbate

The adsorbate used in this study was disperse blue 354(DB 354) and it was used for adsorption studies without any further purification. Its structure was shown in Fig. 1. The synthetic wastewater was prepared by dissolving disperse dye in distilled water for different concentration (1, 5, 10, 15, 20) ppm. The UV-visible spectrum (Shimadzu) of dye Fig. 2 was initially determined and identified the adsorption wavelength (λmax).



Disperse Blue 354
Fig. 1: Structure of Disperse Dye.



Disperse Blue 354
Fig. 2: Spectrum of Disperse dye at different Concentration.

A.III Decolourization Study

Column experiments were carried out to measure decolourization characteristic of DB 354 on adsorbent flyash. Different combination of flyash: sand (1:1, 1:2, 1:3) were tried in order to increase the filteration rate. The column experiments were carried out in a glass column, 40mm i.d., 20cm in height. The column was packed with the different ratio of flyash: sand between two supporting layers of glasswool and glassbeads. The bed depth was 10cm and the filling weight 48.5g.

The dye solution was fed through the fixed bed column in the down flow mode. Before starting the experiment, the bed was rinsed with distilled water and left overnight to ensure a closely packed arrangement of particles with no void or cracks. The dye solution was passed through the column using a peristaltic pump (Watson Marlow). The samples were collected at specific interval of time and measured for the dye concentration by UV-Visible spectrophotometer. The flow to the column was continued until the effluent concentration approached nearly to influent concentration of the dye solution. The effect of both dye concentration at constant bed height and flow rate was examined.

B. Results and Discussion

The specific surface area of flyash obtained from the N_2 equilibrium adsorption isotherm(BET) were found to be 1.2530 ±0.0112 m^2 g^{-1}. XRD shows that adsorbent is crystalline in nature as show in fig.4.The presence of crystalline phases such as quartz (SiO_2), mullite (Al_2O_3), and some oxides confirmed by comparing with (Joint Commission on Powder Diffraction Standards [JCPDS] . The powder diffraction pattern of FA readily indexed to the hexahedral crystalline structure of quartz (Joint Commission on Powder Diffraction Standards [JCPDS] card no.89-1961, lattice parameter:a=4.921Å, c=5.416 Å) and for mullite & haematitite (Fe_2O_3) it resemble with rhomohedral crystalline structure (JCPDS card no.88-0826, lattice parameter: a=4.76Å, c=12.99 Å) and(JCPDS card no.89-2810, lattice parameter: a=5.04 Å, c=13.75 Å). fig. 5. shows the SEM image of flyash. SEM image of flyash is mostly spherical in shape.

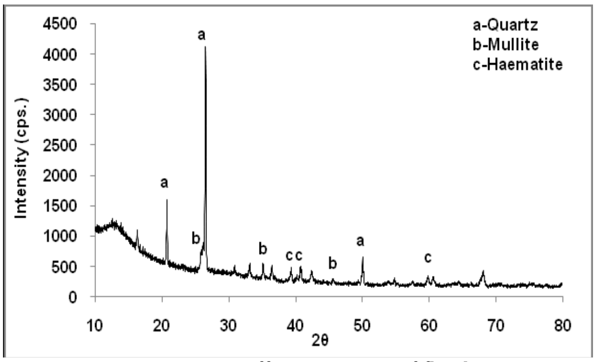


Fig.4: X-Ray Diffraction pattern of flyash

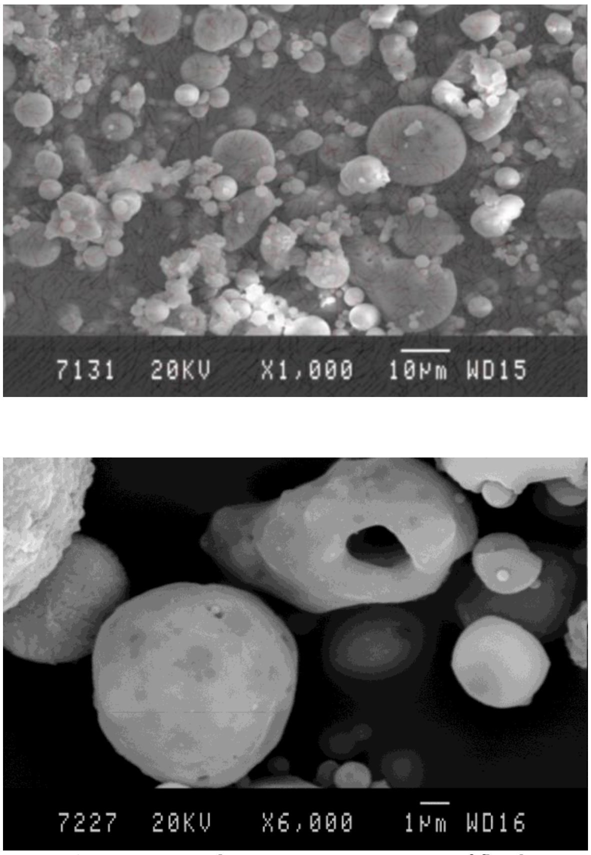


Fig.5: Scanning Electron Microscopy images of flyash

B.I Decolourization of Dyes by Adsorption on Columns

The calculation to determine the percent adsorption of the dyes was made according to the equation:

$$\text{Percentage removal} = \frac{C_{initial} - C_{final}}{C_{initial}} \times 100$$

International Journal of Engineering Research & Technology (IJERT)
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The removal of dyes by adsorption on column composed of flyash and sand mixtures reach equilibrium conditions when the adsorbent mixture stops adsorbing the solute dye. The adsorption equilibrium point is indicated by the concentration of the dyes in the outlet. At this point the concentration of the dye in the outlet becomes nearly equal to the initial concentration.

The percentage removal of disperse blue 354 is shown in fig. 6, 7, 8 . Flyash: sand mixture in 1:1 ratio at different concentration (1, 5, 10, 15, 20)ppm showed good removal efficiency then 1:2 and 1:3 ratio of flyash and sand.

For mixture 1:1, he removal efficiency was found to be 82%, 75%, 74%, 72%and 69% in 30 minutes for concentration (1, 5, 10, 15, 20)ppm, respectively and with increase in time removal efficiency decreases . The same pattern was observed for mixture 1:2 and 1:3 for different dye concentration as shown in fig.7 and fig.8.

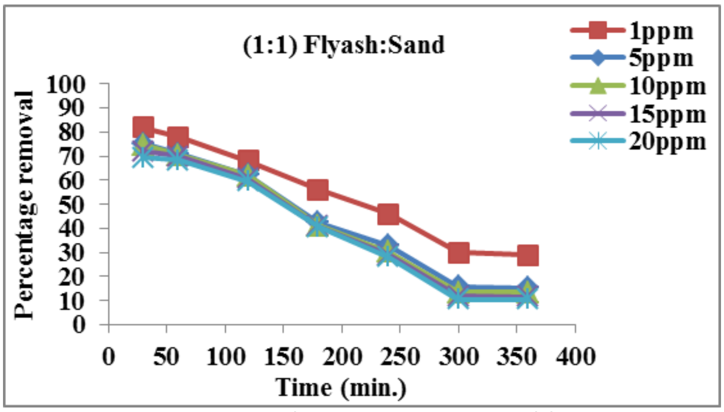

Fig.6: Percentage removal of DB 354 in columns of flyash and sand mixtures in 1:1 ratio from aqueous solutions at different concentration (1, 5, 10, 15, 20) ppm.

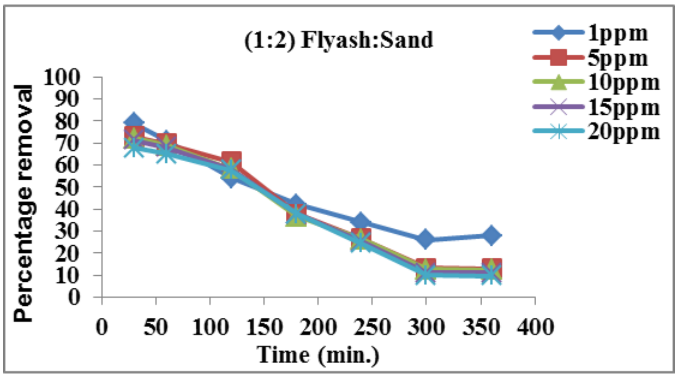

Fig.6:Percentage removal of DB 354 in columns of flyash and sand mixtures in 1:2 ratio from aqueous solutions at different concentration (1, 5, 10, 15, 20) ppm.

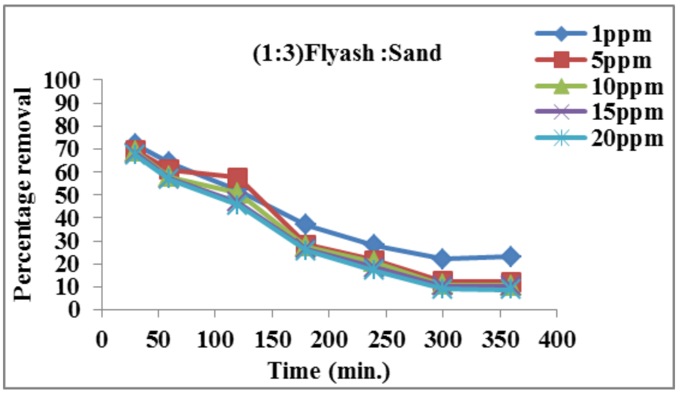

Fig.6: Percentage removal of DB 354 in columns of flyash and sand mixtures in 1:3 ratio from aqueous solutions at different concentration (1, 5, 10, 15, 20) ppm.

The removal of dye decrease with increase in solution concentration from 1 to 20 ppm at room temperature, showing the process is highly dependent on the concentration of solution. Results of above study shown that flyash could be used for decolourization of dye solution in textile wastewater at tertiary level of treatment.

B. Conclusions:

From the present study, it may be concluded that the decolourization of disperse dyes from aqueous solutions by adsorption on flyash and sand mixtures has found to be useful means for controlling the water pollution due to dyes. The important characteristics and results of the present study are:

1. XRD and SEM studies revealed that the flyash which is used as adsorbent for DB354 removal is crysllatine in nature with the presence of Quartz, Haematite, Mullite and other oxides. The presence of SiO_2 and other oxides help in colour removal. SEM images gives exact surface morphology of flyash. Flyash particles are spherical in shape confirmed by SEM images.
2. The removal of disperse dyes from column experiments decrease with increase in solution concentration from 1 to 20 ppm at room temperature, showing the process is highly dependent on the concentration of solution.
3. The best removal efficiency was found to be 82%, 75%, 74%, 72% and 69% in 30 minutes for flyash and sand mixture 1:1 at different concentration while percentage removal for flyash and sand mixture 1:2 and 1:3 was found to be 79% ,73% ,72% ,70% ,67% and 72% ,69% ,69% ,68% ,67% , respectively.

The main advantage of using flyash as adsorbent for dye removal, as flyash is easily available as a waste material in our environment. Adsorption is an effective method for colour removal from textile wastewater due to its easy operation, low-cost, simple design and superior removal of organic waste constituents as compared to the conventional biological treatment process.

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