A STUDY ON REMOVAL OF POLLUTANTS USING FLY ASH ADSORBENT FROM DYES WASTE WATER

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Abstract

The use of low-cost adsorbent has been investigated as a replacement for the current expensive methods of removing dyes from wastewater like chemical degradation, advanced oxidation processes, adsorption, precipitation, biodegradation and chemical coagulation. Fly ash generated in Thermal Power plant and other industries which are extensively using coal is collected and converted into a low-cost adsorbent. The highly porous Fly ashes will be utilized to treat colored effluent of a dyes manufacturing plant.Color in the dyes is resulted to reacted-unreacted chemicals. Such type of effluent content Organic Carbons, turbidity and TSS. Adsorption studies was carried out for different temperatures, pH's, and adsorbent doses. In comparison to other low-cost adsorbents, the sorption capacity of the material under investigation is found to be comparable to that of other commercially available adsorbents used for the removal of cationic dyes from wastewater.

The Fly ash was activated by chemical treatment by N/2 H2SO4. Batch adsorption experiments were performed as functions of adsorbent doses, initial dye concentration, contact time, and pH. The percentage of colour removal was increased with increasing contact time and adsorbent doses. Chemical oxygen demand (COD) reduction wasincreased with increasing contact time and adsorbent doses.Maximum removal of colour and Chemical oxygen demand (COD) have been taken place in acidic medium (pH=5).

Index Terms: Adsorption; Fly ash, Reactive dyes

INTRODUCTON:

Discharge of dye bearing waste water into natural streams from dyes, textile, paper, rubber, plastics, paints, printing, and leather and carpet industries has created serious ecological problems due to persistent nature of dyes [1].The coloration of the water by the presence of dyes, even in small concentration is easily detectible. These dyes usually have a synthetic origin and complex aromatic molecular structure, which make them more stable and more difficult to biodegrade. They have an inhibitory effect on the process of photosynthesis and, thus, affecting the aquatic life. Many dyes may also cause allergic dermatitis, skin irritation, dysfunction of kidney, liver, brain, reproductive and central nervous system. Besides, some are suspected carcinogens and mutagens.[2]

Coloured wastewater is particularly associated with reactive azo dyes that are generally used for dyeing carpet, cotton, wool, silk, and nylon and it is also used in the manufacturing of paints [3]. Now-a-days, these dyes make up approximately 30% of the total dye market. Reactive dyes are the most common dyes are used due to their advantages, such as bright colours, excellent colour fastness and ease of application but due to low biodegradability under aerobic conditions these dyes are toxic and carcinogenic in nature[4].

Wastewater treatment can be done using three methods: primary, secondary and tertiary/advanced processes. Primary treatment separates suspended solids and greases from water and a secondary treatment such as biodegradation process is used in the removal of biodegradable compounds whilst tertiary/advanced treatment methods are largely used to remove non-biodegradable wastes.

Thus, the removal of dyes from coloured effluents of textile industries is one of the major concerns these days. Various techniques like chemical coagulation [5], foam flotation [6], electrolysis, chemical oxidation [7], photochemical degradation [8], membrane filtration [9], biological treatment, adsorption [10] have been used in the past for the removal of dye from the effluents. Most of these techniques are rather expensive and not so effective. But adsorption process has found to be more effective and cheap for the removal of colour from the effluent samples. Although the activated carbon is most effective for the adsorption of dyes, but it is quite expensive due to non- renewable and relatively expensive starting material such as coal. Therefore, the development of low cost alternative adsorbents has been the focus of recent research [11]. Many researchers have utilized a number of substances such as agriculture waste: coir pith [12], banana pith [13], sugarcane dust [14], sawdust [15], rice husk [16], orange peel [17], apple pomace and wheat straw [18], neem husk [19], wood material, industrial solid wastes: fly ash, bottom ash, red mud [20-21], shale oil ash etc.

Fly ash is one of the waste materials originating in great amounts in combustion processes. In other words, Fly ash is a kind of waste product generated from Thermal Power Plants, which is the major cause environmental pollution. Although, significant quantities of fly ash are being used in various applications, but large quantity of this is not used and this requires disposal. For reducing environmental pollution, research is, therefore, needed to develop new environment friendly applications that can further exploit fly ash [22].

RESEARCH METHODOLOGY

Characterization of Adsorbents

Fly Ash was collected from the Thermal Power Plant, Torrent power (Ahmedabad) India was washed several times with distilled water and left to dry and, then, subjected to chemical activation. Fly Ash sample was soaked in N/2 H2SO4 solution for 24 hrs. Then it was filtered and dried into oven at 60^0C for overnight. This Flyash was used for study purpose.

Table: 1 ChemicalComposition of Fly Ash

Sr No	Characteristics	Test Protocol	Test Results
1.	Magnesium as MgO	IS 5949:1990	**0.91%**
2.	Sodium as Na_2O	IS 9749:2007	**0.40%**
3.	Potassium as K2O%	IS 9749:2007	**1.91%**
4.	Iron as Fe_2O_3	IS 1760 Part 3: 1992	**5.23%**
5.	Silica as SiO_2	IS:1355: 1984	**65.79%**
6.	Alumina as Al_2O_3	IS1760 :1992(Part 3)	**21.76%**
7.	Calcium as Cao	IS 5949:1990	**1.26%**
8.	Titanium as TiO_2	IS 1917 : Part 7	**1.18%**
9.	Phosphorous as P_2O_5%	ASTM D5759 1995 (Reapproved 2005)	**0.063%**
10.	Sulfur as SO3	ASTM D5759 1995 (Reapproved 2005)	**0.55%**
11.	Manganese as MnO	ASTM D5759 1995 (Reapproved 2005)	**0.04%**

*Source: Torrent Power Thermal Power Plant, Ahmedabd

Adsorbate Solution

The effluent Sample was collected from secondary clarifier outlet of ETP which is engaged in manufacturing of Reactive dyes. Unit is having Primary, Secondary and Advanced treatment units. A study was carried out on Secondary Clarifier outlet Sample.

Table: 2 Dyes waste water Sample characteristics

Parameters	Secondary Clarifier Outlet.
Colour (Cu-Pt Unit)	600 Pt.Co Scale
pH (pH Unit)	7.34
COD (mg/L)	1036 mg/L

Batch Studies

In batch test the required amount of adsorbate solution was added in the 250 mL beaker. Batch adsorption experiments were carried out at room temperature by varying mixing time, adsorbent doses, and pH values on a magnetic stirrer using 250 ml screw-cap conical flasks containing 100 ml of dye solution and agitation speed of adsorbate and adsorbent was done in stirrer at 350-400 rpm. Adsorption Procedure In this study, batch sorption process was employed to find out the optimum experimental parameters including pH, adsorbent dosage, and contact time.

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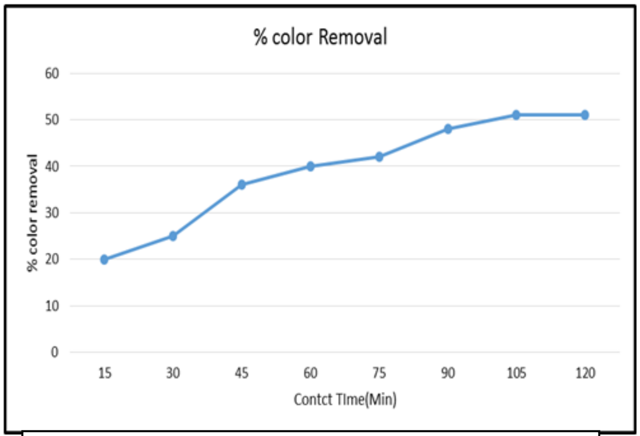
RESULTS AND DISCUSSION:

Effect of Contact Time

The influence of contact time of adsorbent on the adsorbate through adsorption process of was also evaluated by performing various batch tests with changing stirring time from 15 minutes to 120 minutes wherever required. The effluent and adsorbent mixture was placed in the shaker at 350 rpm for particular minutes maintaining room temperature to perform the batch experiment. The samples were then analyzed to determine the concentration of Color and COD.

Table 3: Effect of mixing time on adsorption equilibrium

Contact Time (Minute)	Removal of Color (%)
15	20
30	25
45	36
60	40
75	42
90	48
105	51
120	51

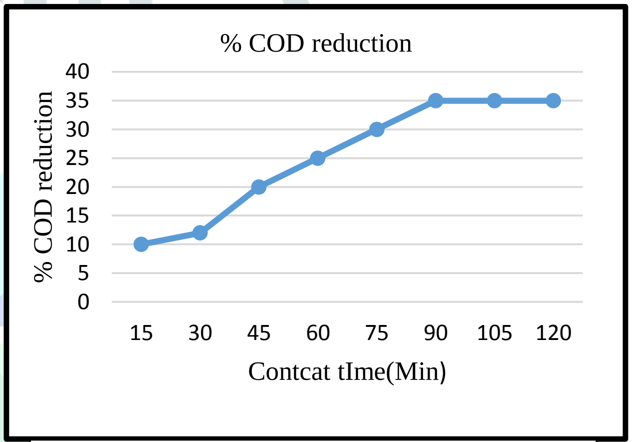


Initial color Concentration: 600 Pt.Co scale, pH =7.3 at 30ºC, Agitation speed 350 RPM

Fig: 1 Effect of mixing time (mins) on Color removal

Table 4 : Effect of mixing time on adsorption equilibrium

Contact Time (Minute)	Removal of COD (%)
15	10
30	12
45	20
60	25
75	30
90	35
105	35
120	35



Initial COD Concentration: 1036 mg/L , pH =7.3 at 30ºC, agitation speed 350 RPM,

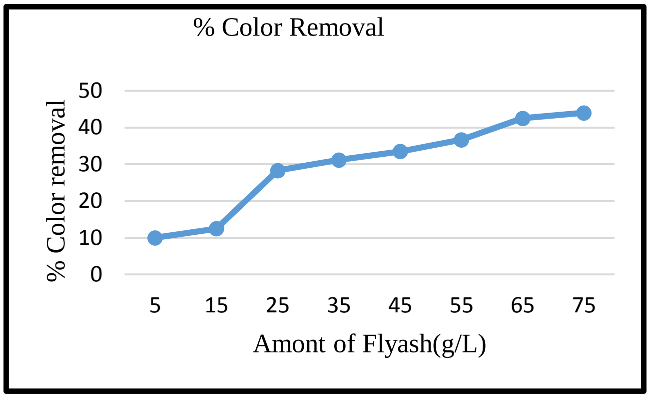
Fig: 2 Effect of mixing time (mins) on COD reduction

Effect of Adsorbent Doses on Adsorption Equilibrium

In order to find out the optimum adsorbent dosage, number of various batch tests were performed with different amounts of adsorbents in grams. Different amounts of adsorbents were measured by an digital balance. For each batch test initial organic compound as COD (Chemical Oxygen Demand) concentration was chosen as 1036 mg/L and colour concentration 600 Pt.CO Scale in 250 mL solution . Increases in adsorbent dose increased the percentage removal of color and organic compound as shown in fig.3 & 4, which is due to the increases in adsorbent surface area of the sorbent.

Table: 5 Effect of adsorbent doses on adsorption equilibrium

Adsorbent Dosage (g/L)	Removal of Color (%)
5	10
15	12.5
25	28.3
35	31.2
45	33.5
55	36.7
65	42.5
75	44

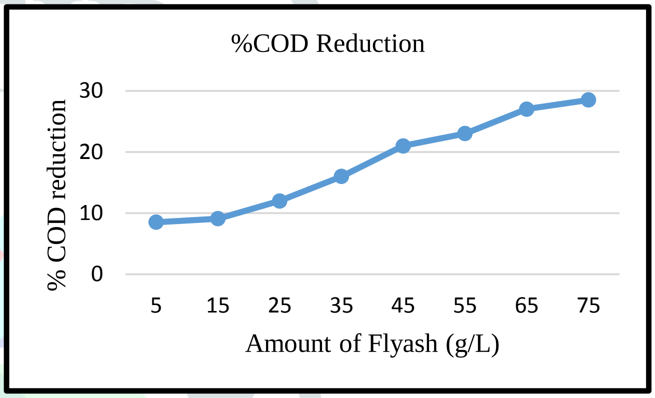


Initial color Concentration: 600 Pt.Co scale, pH =7.3 at 30ºC, agitation speed 350 RPM,

Fig: 3 Effect of the adsorbent doses (Fly ash) on color removal

Table: 6 Effect of adsorbent doses on adsorption equilibrium

Adsorbent Dosage (g/L)	Removal of COD (%)
5	8.5
15	9.1
25	12
35	16
45	21
55	23
65	27
75	28.5



Initial COD Concentration: 1036 mg/L,
pH =7.3 at 30ºC,
Agitation speed 350 RPM.

Fig: 4Effect of the adsorbent doses (Fly ash) on COD reduction

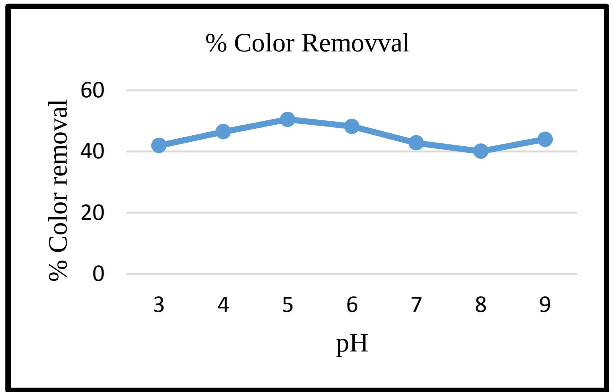
Effect of pH on Adsorption Equilibrium

In order to find out the optimum pH for Colour removal and organic matter reduction through adsorption onto the Fly ash adsorbent, number of batch tests were performed with different initial pH of 3,4,5,6,7,8, 9 . The pH variation was conducted by adding either 5N H2SO4 or 1 N NaOH in the dyes effluent and mixing for 2-3 minutes. The initial pH of the solution for each batch test was measured by a pH meter.

The mixture was placed in the shaker at 350 rpm to perform the batch experiment at room temperature. Samples were collected at 30, 60, 90, and 120 minutes, and then filtered and stored in glass Nessler tubes. The stored samples were then analysed. All batch tests were conducted in a similar way as described above, and the only exception was to maintain a different initial pH value for each batch test. The optimum 6 was then determined as the pH at 5 which the highest color removal was obtained. In case of COD the pH value of 5 was found to be optimum.

Table:7 Effect of pH on adsorption equilibrium

pH	Removal of Color (%)
3	42
4	46.5
5	50.5
6	48.2
7	42.8
8	40.1
9	44

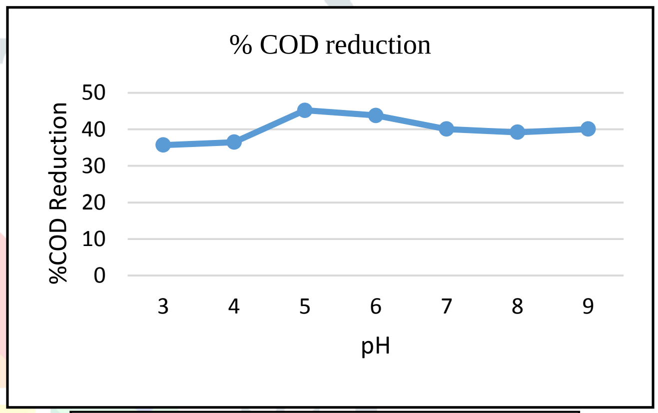


Initial color Concentration: 600 Pt.Co scale at 30ºC, agitation speed 350 RPM

Fig:5 Effect of pH on color removal

Table:8 Effect of pH on adsorption equilibrium

pH	Removal of COD (%)
3	35.7
4	36.5
5	45.2
6	43.8
7	40.1
8	39.2
9	40.1



Initial COD Concentration: 1036mg/L at 30ºC, agitation speed 350 RPM

Fig: 6 Effect of pH on COD reduction

CONCLUSION

In this work, the Fly Ash activated by N/2 H_2SO_4 has been used successfully as an adsorbent for the removal of color and organic pollutants from the dyes effluent. Experiments were performed at room temperature (30ºC) as a function of mixing time, concentration of dye, effect of adsorbent dosage, effect of pH. Based on the experimental data, Fly Ash was an effective adsorbent for the removal of color as well as COD reduction from Dyes effluent. Removal efficiency increased with increasing adsorbent dose and mixing time but after a certain point a saturation point was appeared. The result of pH shows that the adsorbent was effective in acidic medium (pH=5). This is attributed to the increasing electropositive charge of the adsorbent which favoured the adsorption of dye anions due to the electrostatic attraction.

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