International Journal of scientific research and management (IJSRM)
||Volume||2||Issue||5 ||Pages|| 842-845 ||2014||
Website: www.ijsrm.in ISSN (e): 2321-3418

Fly Ash as Low Cost Adsorbent to Remove Dyes

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Abstract: *Fly ash, a residue from thermal power plant, is a waste material. It was investigated as new alternative low cost adsorbent to lower methylene blue dye concentration from synthetic waste stream which represent textile wastewater. Potential of adsorbent was identified by doing characterization. Before using fly ash as adsorbent, it was physically activated. Activation process is described in upcoming section. Wastewater stream was prepared synthetically to create artificial actual scenario.In the present study, studies were conducted as a function of adsorbent dosage, temperature, concentration dosage, and pH on adsorption process. We found that, there is no considerable effect of temperature on adsorption. We only check for Freuindlich adsorption isotherm. As regression co-efficient is 0.8351, we can't say that all adsorption data is well fitted in this isotherm model.*

Keywords: Adsorption, Methylene Blue, Fly Ash, Adsorption Isotherm

1. Introduction

Discharge of hazardous wastewater without further treatment can seriously damage the environment. Sunlight and oxygen are very important requirements of aquatic life, but the coloured discharged effluents inhibit penetration of sunlight and oxygen. It adversely affects on life [1]. We have to remove dyes from wastewater of dyeing and finishing operation in textile industry. In process of washing and finishing coloured products, wastewater contaminated with dyes is generated [2].Trickling filter, activated sludge, chemical coagulation and flocculation, oxidation, ozonation, membrane separation, photo degradation, and adsorption processes are most conventional waste water treatment technologies [3-6]. Though these techniques are most effective, includes high initial cost and operating cost. Some of them are not feasible on large scale. Physical adsorption has received considerable attention as an effective method for removing the concentration of dissolved dyes in waste streams [7, 8]. We can achieve desired degree of removal as economical solution by choosing appropriate adsorbent which is omnipresent at low cost. Research has been done on. Previously, many low cost adsorbent have been investigated on dye removal, such as fly ash [9-13], bottom ash [14], clay [15], zeolite [15-16], calcine alunite [17], peanut hull [18], rice husk [19], and brown seaweed [20]. Fly Ash, is a waste substance from thermal power plants, steel mills, etc that is found in abundance. Waste utilization is gaining importance for controlling pollution.

2. Materials and Methods

2.1 Preparation of Activated Flyash

Fly ash used for the work is collected from the "Deepnagar", Thermal Power Station, near Jalgaon(Maharashtra, India). Fly ash is sieved to remove unwanted materials. Fly ash is washed with water (50 g with 500 ml of water- 5 times). Washed fly ash is activated by heating it in oven at 110 ^{0}c for 24 hours. Activated fly ash is again sieved to obtain desired size of particles (52 meshes).

2.2 Stock Solution

Stock solution was prepared by dissolving 1 gram of Methylene Blue Dye in 1 liter double distilled water. And afterwards, it was diluted in double distilled water as per our requirement.

2.3 Characterization of Flyash

The diffractogram, fig 1, shows the X-ray diffraction pattern for particle size is 52 μm. It was found that the fly ash consisted of crystalline minerals mullite, quartz, hematite and small amounts of calcium oxide with large characteristic peaks of quartz (SiO_2). This result is similar to that reported for a fly ash investigated. The intensity of quartz is very strong, with mullite forming a chemically stable and dense glassy surface layer. The low calcium oxide intensity is characteristic of low-Ca Class-F CFA

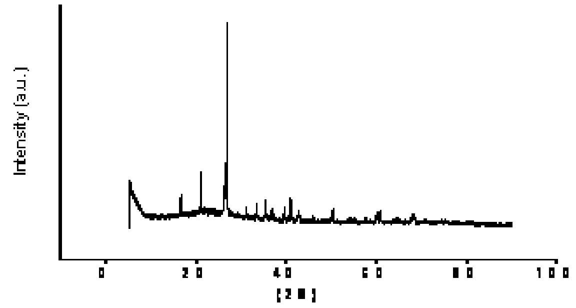

Figure 1: X-ray diffraction pattern

3. Batch Experiments

3.1 Effect of Adsorbent Dosage

The effect of adsorbent dosage on the amount adsorbed was obtained by agitating 60 mL of MB solution of concentration 0.5g/L with 3, 5, 7, 9, 11 g of Fly Ash at room temperature for 60 min at a constant stirring speed

3.2 Effect of Temperature

The effect of temperature on amount adsorbed was obtained by agitating 60 mL of MB solution of concentration 0.5g/L with 3 g Fly Ash at temperature 60, 70, 80, 90, 100 ºC for 60 min at a constant stirring speed.

3.3 Effect of Concentration Dosages

100 ml of dye solution was prepared in different conical flasks with different dye conc.(1g/L, 0.75g/L, 0.5g/L, 0.25g/L, 0.125g/L) and adsorbent 5g/60ml. The final dye concentration readings were taken after putting the 5 flasks inside the taken for 24 hours. A plot of % q e vs concentration dose is taken.

3.4 Effect of pH

100 ml of dye solution was prepared in a conical flask with dye conc. 0.5gm/L and adsorbent conc. (1g/60ml) and initial pH of the conical flask is to be measured. The pH of the dye solutions was adjusted with dilute HCl (0.05N) or KOH (0.05N) solution by using a pH meter (EUTECH Instrument, pH 510).100 ml of dye solution was prepared and the pH of solution is changed from 3 to 11.The flasks were placed on magnetic stirrer (120rpm fixed throughout the study) maintained at 27 ^{o}C and the final concentration of dye was measured using UV spectrophotometer and the calibration plot of the dye after 2 hours. A graph is to be plotted with % qe vs initial pH.

3.5 Percentage Removal

The percentage adsorption of metal ion was calculated as follows:

$$\%\ Removal = \frac{(Co-Ce)}{Co} * 100$$

Co-Initial Concentration of MB,Ce- Concentration of MB at respective time interval

3.6 Sample Analysis

The total concentration of MB in solution was determined according to the standard methods of analysis using UV – Visible Spectrophotometer at λ = 665 nm(JASCO UV/Vis-550)

4. Results and Discussion

The standardization of UV reading for known concentration of Methylene blue in aqueous solution is done. The graph shown below, fig.2, gives the concentration values of methylene blue for the UV reading. Thus one can find out the concentration of methylene blue in aqueous solution from the given known UV-Visible reading. The adsorption of MB on the Fly Ash was investigated as a function of the adsorbent dosage, concentration dosage, pH and temperature. The performance of Fly Ash for the MB removal using the experimental equilibrium data for Freundlich adsorption isotherms was tested.

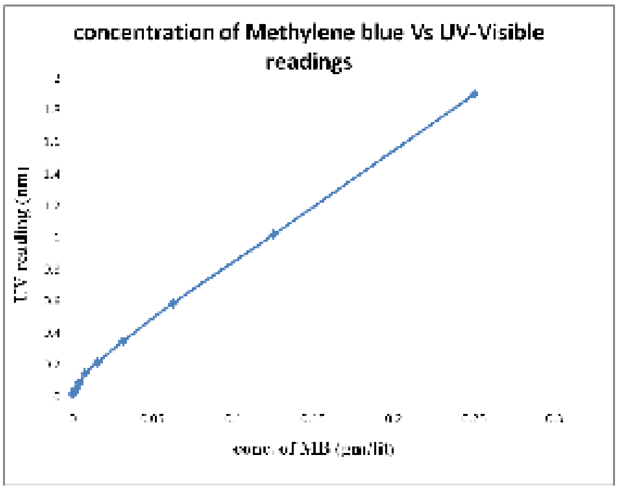

Fig.2Concentration of MB verses UV reading

4.1 Effect of Adsorbent Dose

Fig.3 shows the effect of adsorbent dose on percentage removal. In the cases i.e. where fly ash is used as adsorbent, the sorption efficiency increased with an increase in adsorbent dosage. This is due to an increase in the surface area of the adsorbent which in turn increases the number of binding sites. But as we are going to increase adsorbent dose, we should consider that system is continually being bulkier. So, further studies carried out at lower adsorbent dosage for simplification of operation. It let to decrease in removal efficiency.

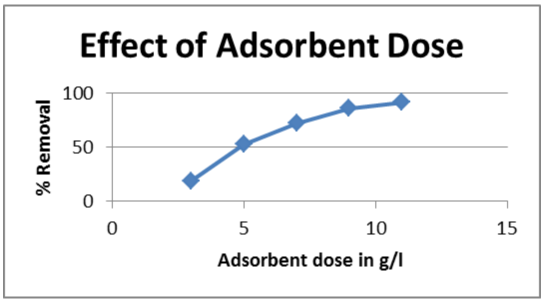

Fig3: Effect of Adfsorbent Dose

4.2 Effect of Temperature

It was observed that there is no considerable effect of higher temperature on removal efficiency. So, we can perform other studies as function of different parameter at room temperature simply.Effect of temperature on removal is indicated in fig.4.

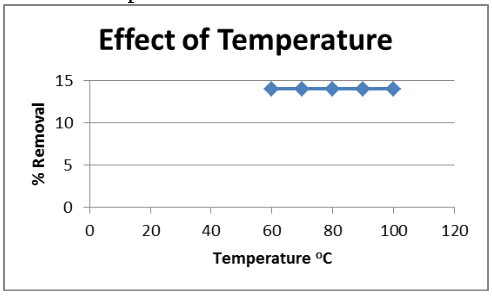

Fig 4: Effect of Temperature on percentage removal

4.3 Effect of Concentration Dosage

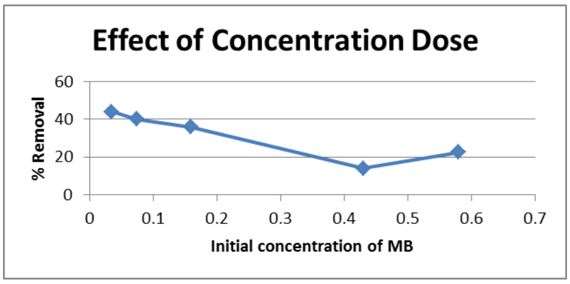

Fig5: Effect of Concentration dosage

Fig.5 depicts the effect of concentration dosage on removal. One can predict that as concentration of methylene blue increases the per cent adsorption decreases for constant amount of adsorbent due to insufficient adsorption sites at adsorbent.

4.4 Effect of pH

The effect of pH on percentage removal is shown in fig.6.In This case pH is increased from 3 to 11. It appears that silica and alumina , which are chief constituents of fly ash, form metal –hydroxide complexes in solution & the subsequent acidic or basic dissociation of these complexes at the solid solution interface leads to either positive or negative surface charge [21].At acidic pH, the dissociation of the metal hydroxide complexes causes the surface to become positively charged. However, with increasing pH, the surface becomes negatively charged as in the alkaline medium the silica and alumina get converted into SiO_2- and Al_2O_3- type of functional sites and, therefore, the binding of positively charged dyes onto these surfaces become much favourable resulting in enhanced adsorption of dyes [22-23].The variation of adsorption with pH can be explained by considering the difference in the structure of the dyes, as well as the point of zero charge of the fly ash (which is 5.8). The main constituents of fly ash are silica and alumina. The ZPC (a concept; related to the adsorption process; describes the condition when the electrical charge density on a surface is zero) of silica is 2.3, while that of alumina is 8.2, and as such the surface of fly ash would have high positive charge density below pH value of 5.8, i.e. ZPC of the fly ash[a]. Under these conditions the uptake of positively charged dyes would be low; with increasing pH, the negative-charge density on the surface increases resulting in enhanced removal.

4.5 Adsorption Isotherms

From fig.7, it clearly seen that we didn't have linearized adsorption isotherm. Only Freundlich isotherm model has been employed to evaluate the adsorption data for methylene blue. Freundlich isotherm is based on the assumption of uniform energy throughout concentration of methylene blue. Freundlich isotherm can be expressed for the given system as, Y=0.613 and X= 0.033.

5. Conclusion

In this study, the adsorption of Fly Ash was investigated and the following conclusions can be drawn.

1. The uptake capacity of methylene blue increased with increasing adsorbent dosage.
2. There is no effect of temperature on removal efficiency.
3. The concentration of methylene blue increases the % adsorption decreases for constant amount of adsorbent.
4. In Case of methylene blue higher pH, increased the rate of adsorption.
5. The adsorption isotherm was not well described by Freundlich model.

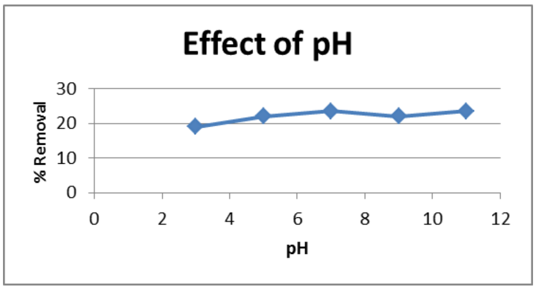

Fig 6: Effect of pH

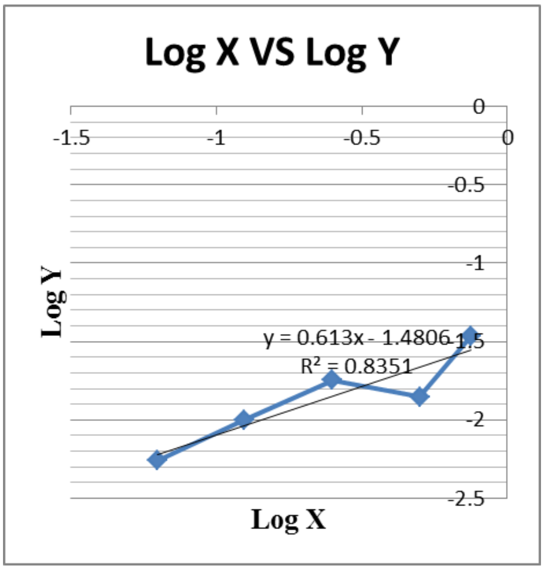

Fig.7 : Freundlich isotherm model

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