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Adsorption of Copper (II) ions from Synthetic Waste Water By Fly Ash

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***Abstract*— The adsorption process is being widely used by various researchers for the removal of heavy metals from waste streams and activated carbon has been frequently used as an adsorbent. Despite its extensive use in the water and wastewater treatment industries, activated carbon remains an expensive material..In the present study, Fly Ash was investigated as adsorbent for removal of copper ions from synthetic waste water. Batch experiments were carried out to investigate the effect of contact time, adsorbent dosage, and temperature. The values of optimum parameters were found. The optimum time is between 40 to 60 minutes. The adsorbent dose of 2 g/l was found to be optimum. The equilibrium adsorption data were fitted to Langmuir and Freundlich adsorption isotherm models and model parameters were evaluated. The results show that Fly Ash can be employed as it is (after physical activation) to use it as low cost adsorbent for adsorption of Cu (II) from aqueous solution.**

***Index Terms*— Adsorption, Cu (II), Fly Ash, Langmuir isotherm, Freundlich isotherm**

I. INTRODUCTION

In this era of rapid indusrilization heavy metal pollution has become one of the most important environmental problem. Unlike organic pollutants, heavy metals are essentially non-biodegradable and hence are accumulated in living organisms. Some metals such as Cd, Hg, Ag and Pb can become extremely toxic to living beings, others such as Cu, Zn, Mn, Fe, Ni and Co though essential for plant and animals, when present in excess concentrations and above certain limits, can be very harmful to living organisms. Copper is considered as micronutrient but is extremely toxic to living organisms at higher concentrations. The main sources of copper pollution are metal cleaning and plating baths, paints and pigments, a pulp, paper board mills, wood pulp production, and the fertilizer industry [1, 2]. Copper may also be found as a contaminant in food, especially shellfish, liver, mushrooms, nuts, and chocolate [3]. The World Health Organization (WHO) recommends a maximum acceptable concentration of Cu (II) as 1.5 $mg.L^{-1}$ in drinking water. It has been reported that excessive intake of copper by humans leads to hepatic and renal damage, capillary damage, gastrointestinal irritation and central nervous system irritation. Conventional methods include chemical precipitation, adsorption, oxidation or reduction, coagulation, filtration, ion exchange, application of membrane technology, solvent extraction and evaporation. However, these processes have considerable disadvantages including incomplete metal removal, requirement of expensive equipment and monitoring systems, large reagent or energy requirements or generation of toxic sludge or other waste products that require disposal. Among these adsorption, an alternative technology for conventional wastewater treatment, has received considerable attention for the development of an efficient, clean and cheap technology [4-7]. In recent years, attention has been focused on the removal of copper from aqueous solution using adsorbents derived from low-cost materials. Many researchers have investigated low-cost materials as a viable adsorbent for heavy metal removal, namely, cashew nut shell [4], rice husk [8], Sugarcane Bagasse [8], peanut shells [9], activated sludge [10], brewery biomass [11], ipomoea carnea [12], cassava [13], teak leaves [14,15], fly ash [16]. The need for a cost-effective process and a safe method for removing heavy metals from discharging effluents have resulted in the search for other unconventional materials such as organic or inorganic sorbents.

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II. MATERIALS

A.Adsorbent

Fly ash used for the work is collected from the Deepnagar, Thermal Power Station, (Varngaon), Bhusawal near Jalgaon. Fly ash is sieved to remove unwanted materials. Fly ash is washed with water (10 gm with 100 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 mesh).

B. Synthetic Waste Water

Analytical grades of $CuSO_4.5H_2O$ were purchased from Merck, India. Stock solution of copper concentration 1000 mg/L was prepared by dissolving 3.93 g of 100% CuSO4·5H2Oin 1000mL of distilled water. The solution was prepared using standard flasks. The concentration of the metal solution of 20 mg/L prepared by diluting stock solution.

III. METHOD

For Adsorption studies, desired quantities of the chosen adsorbent Fly ash were mixed with 100 ml of Cu (II) solution in 250 ml conical flasks. The flasks were placed on a magnetic stirrer at 120 rpm and the samples were taken at regular time intervals. The experiments were carried out at different adsorbent dosage (5-25g/l), temperature (30-75°C). The samples were then filter. The Cu (II) content in the supernatant was determined according to the standard methods of analysis using Atomic Absorption Spectrometer at λ = 324.8 nm.

The amount of the metal adsorbed (mg) per unit mass of adsorbent was obtained by using the equation:

$$q = (Co - Ce) * \frac{V}{W}$$

Where,
q is amount of metal ion adsorbed per gram of biomass in $mg.g^{-1}$,
Co is the initial metal ion concentration in $mg.L^{-1}$,
Ce is the final metal ion concentration in $mg.L^{-1}$,
V is the volume of the reaction mixture in liter, and
W is the weight of biomass in the reaction mixture in mg.
The percentage adsorption of metal ion was calculated as follows:

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

IV. RESULT AND DISCUSSION

The adsorption of copper (II) ions on the Fly Ash was investigated as a function of the contact time, adsorbent dosage and temperature. The performance of Fly Ash for the copper (II) removal using the experimental equilibrium data for Langmuir and Freundlich adsorption isotherms was tested.

A. Effect of contact time

Contact time is an important factor affecting removal; most of adsorption occurs in initial half an hour and increases very slowly later. Further increase in contact time tends to decrease adsorption due to desorption. Adsorption is increases with respective time after 60 minute in case of Fly Ash.

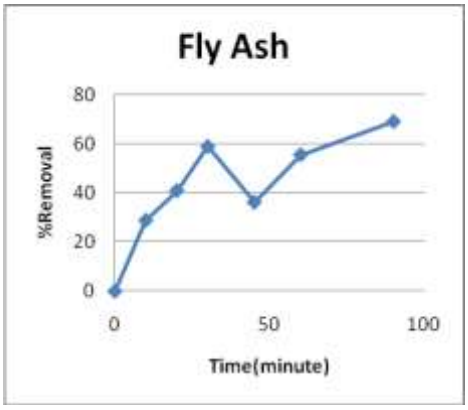


Figure1: % Removal V/s Time at 20 $mg.l^{-1}$ (ppm) concentration and for Fly Ash. (Adsorbent dose: 1g/l, Temperature: Room Temp.)

B. Effect of Adsorbent Dosage

For fly ash, 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. 2 g/l was optimum dose.

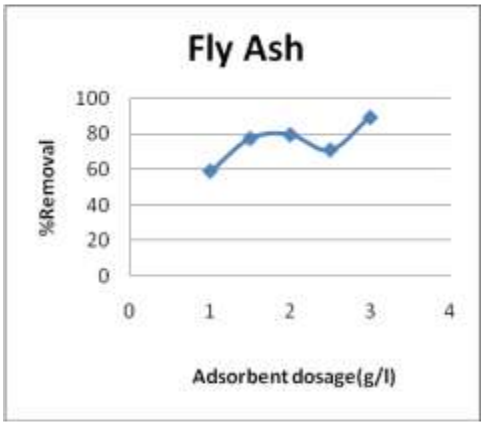
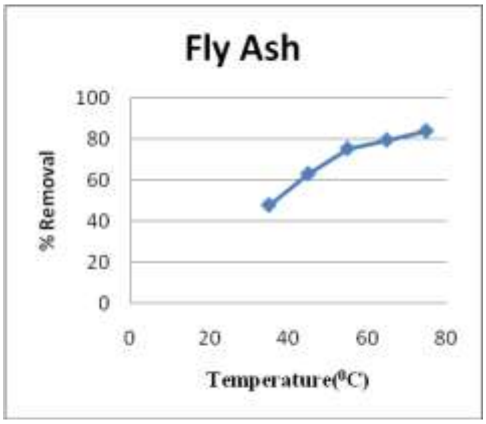


Figure2: % Removal Vs Adsorbent Dosage for 20 mg/L (ppm) solution of copper for FlyAsh. (Contact time: 60 min, Temperature: Room Temp)

C. Effect of Temperature

In the case of adsorption by Fly Ash was found to increase with increase in temperature and interactions are found to be endothermic in nature and these results are similar to observation have been reported in earlier research.



D. Adsorption Isotherm

The linearized Langmuir and Freundlich adsorption isotherms obtained at room temperature are shown in figure 4 and 5 and adsorption coefficients computed from these are given in table. All the curves had good linearity (correlation coefficient) indicating strong binding of copper (II) ions to the surface of particles.Fly Ash from Langmuir isotherm, the adsorption affinity constant (*b*) and maximum capacity (q_{max}) of the ion copper (II) estimated as -0.117 and 0.041 g/g, respectively. For Freundlich isotherm the constants related to the adsorption coefficients (K_f) and intensity (*m*) were 1.009 g/g and -1.039, respectively. The correlation coefficients obtained from the Langmuir model and Freundlich model were 0.946 and 0.959, respectively.

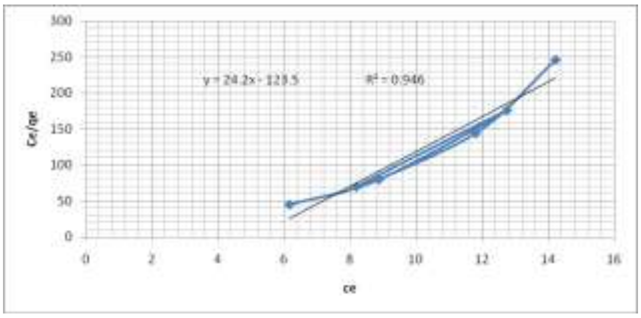


Figure 4: Langmuir adsorption isotherm for copper at 1g/100mL of mass concentration of Fly Ash

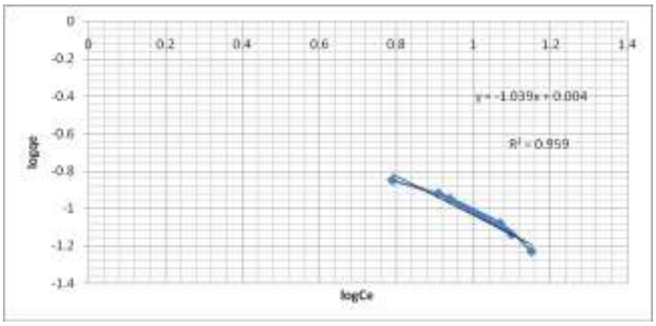


Figure 5: Freundlich adsorption isotherm for copper at 1g/100mL of mass concentration of Fly Ash

Table 1: Langmuir and Freundlich model parameters estimated from the fitting of experimental points of copper (II) adsorption

Adsorbent	Langmuir Isotherm			Freundlich Isotherm		
	q_{max}	R^2	B	K_f	R^2	M
Fly Ash	0.041 g./g	0.946	-0.117	1.009	0.959	-1.039

V. CONCLUSION

In this study, the adsorption of copper by Fly Ash was investigated and the following conclusions can be drawn. The adsorption performance is strongly affected by parameters such as contact time, adsorbent dosage and temperature. As contact time increases % removal also increases but after some time desorption also become dominant and % removal can be decreases. So from result we can optimise contact time to 60 minutes. Then, % adsorption of copper (II) increases with increasing adsorbent dosage. As adsorbent dose increases, copper get more surface area available to adsorb on adsorbent. % removal increases with temperature. The Fruendlich model proved to be the best adjustment of the experimental data for fly ash. The present work helped in identifying a new source of adsorbent for removal of metals from effluent wastes containing low concentrations of metals.

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