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Optimization of Copper Ion Removal from Wastewater by Using Coal Fly Ash

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Abstract— Most of the adsorbent used for used for removal of heavy metal is activated carbon. It is an expensive material, so that the use of alternative and cheaper adsorbent, which formed as coal fly ash. The coal fly ash is a waste material that generate from industrial processes, but has potential to adsorb copper metal ion. By using this material was removing copper metal ion by using batch experiments in that is Single Metal Solution (SMS). The adsorption data obtained for the experimental work form Freundhich adsorption isotherms. It was found that particle size of coal fly ash 90µ and300 µ mesh removed 84.49%, 81.86%, copper metal ion within contact time concentration is 60 min.
Keywords— Coal fly ash, Metal ion solution, Freundhich Isotherm, Adsorption.

I. INTRODUCTION

The treatment of this type of wastewater involves adsorption techniques such as solvent extraction, adsorption, filtration, precipitation, ion exchange, biological treatment and destruction technique such as ozone process and oxidation. In this regard, coal fly ash is a very attractive alternative because coal fly ash is cheap, widely available. Coal fly ash obtained from the combustion of powdered coal as a waste product. Fly ash quality depends on coal ash type, coal ash particle are fineness, percentage of coal ash in coal, combustion technique, air fuel ratio and boiler type. Much of this coal fly ash however, is capable to have recovered and used. Example of these applications are additives for immobilization of industrial and water treatment wastes, extraction of valuable metals, such as Al, Si, Fe, Pb, Ni, Zn, Cd, Cu. Among all of adsorption, methods are the most effective and economical because of their relative low cost.

The objective of this study is to use coal fly ash as a low- cost waste material in removing and recovery of heavy metals from industrial wastewater. Precipitation leads to complete removal of heavy metals by formation of hydroxide ions, but absorption i.e. adsorption surface precipitation could be more effective to immobile metallic ion fly ash. The main goal of this study was to use coal fly ash as an adsorbent of cations within experimental condition.

II. MATERIALS AND METHODS

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A. Adsorbent

Preparation of activated carbon by using Coal Fly Ash (CFA): Coal fly ash was collecting from burning of coal at the time of metallurgical process in the foundry industry. This CFA had converted into activated carbon by using fractional distillation methods and burning at high temperature. This CFA had washed with tap water to remove any dust and foreign particles attached to CFA and thoroughly rinsed with distilled water. The washed CFA had dried at 50ºC, and then thoroughly washed with clear distilled water until the color of washing water is clear. The powdered CFA had dried in an oven at 50ºC to a constant weight. The CFA was again ground to powder and was sieved with three different sized meshes. Three different grades particle sizes were obtained. First particle size was 90µ and second particle size was 300µ. All the particle sizes were selected for further study.

B. Adsorbate

Stock solutions of metal ions : Stock solution was prepared in de- ionized water from the respective sets of five metals (Pb2+, Cu2+, Zn2+, Ni2+ Cd2+) under investigation. The resulting stock solutions are stored in the airtight plastic bottle.

C. Analysis

The concentration of metals ions in the solutions before and after equilibrium had determined by Perkin-Elmer 3100 Atomic Absorption Spectrophotometer. For the toxic metal the concentrations copper metal ion in the solutions before and after equilibrium

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had determined by Perkin-Elmer 3100 Atomic Absorption Spectrophotometer.

D. Adsorption Experiment

Batch Studies of SMS (Single Metal System): For SMS, solutions of fixed volume (100 ml) with varying concentrations in conical flasks were thoroughly mixed with 0.5 g of activated carbon (coal ash) dose, size of 90µ, 300µ. at 30°C and 150 revolutions per minute (RPM) shaking speed for 5 min, 10 min, 30 min, 60 min. Thirty hours of equilibrium period of adsorption experiment were used to ensure equilibrium after conducting equilibrium studies of the adsorbent. The pH range was adjusted from 4 - 6 by using 0.1Molar HNO3 and 0.1 Molar HCl solutions. The conical flasks were kept on a rotating shaker with constant shaking in centrifuge machine. At the end of the experiment, the conical flasks were removed and the solution was separated from the biomass by filtration through Whatman filter paper no 41. At the end of the experiment, the solution had separated from the activated carbon (coal ash) dose by filtration through Whatman filter paper no 41. Filtrates of SMS are diluted with de-ionized water to the concentrations was 10 mg/ L-1 or 20 mg L-1 and then analyzed for metal concentration by using Perkin-Elmer 3100 Atomic Absorption Spectrophotometer. After metals concentration analysis of metals, the final concentration of metals had subtracted from the initial concentration in order to find the metal to be adsorbed.

E. Calculation of Metal Uptake

The quality of activated carbon (coal ash) dose is judged by the metal uptake (adsorption capacity), q. The amount of metal bound by the activated carbon (coal ash) dose was disappeared from the solution was calculated based on the mass balance for the adsorbent in the system.

Q = V (C0- Ce)/S
q = Metal ion uptake capacity (mgg1).
C0 = Initial concentration of metal in solution, before the adsorption analysis (mgL-1).
Ce = Final concentration of metal in solution, after the adsorption analysis (mgL-1).
S = Dry weight of activated carbon (coal ash) adsorbent in (g).
V = Solution volume (L).

The Freundlich isotherm: The Freundlich isotherm model is an empirical relationship describing the adsorption of solutes from a liquid to a solid surface and assumes that different sites with several adsorption energies are involved. Freundlich isotherm model is the relationship between the amounts of nickel adsorbed per unit mass of adsorbent qe and the concentration of the nickel at equilibrium, Ce.

$$qe = Kf\ Ce1/n$$

The logarithmic equation becomes,

$$\log qe = \log Kf + 1/n \log Ce.$$

III. RESULT AND DISCUSSION

The study explains the removal of copper metal ion concentration at the contact time 60 min. Whereas in this case, the 1.49 % removal was increased 84.59 % with the increased in initial concentration copper 90µ size coal fly ash and 100ppm metal ion as shown in table no1. From table no.I, it was revealed that the contact time of Cu metal concentration vary from 5 min. to 60 min., then the removal efficiency for 5 min. shaking time was 13.78 % the lowest and 81.86% was the highest value of copper metal ion. The removal of Cu % in 90µ is shown in Fig. 1. (a) to (c) and removal of Cu % in 300µ is shown in Fig. 1. (d) to (f).

TABLE-I: Removal of Cu percentage in 90µ and 300µ coal fly ash

Time (min)	Removal of Cu percentage					
	90µ			300µ		
	10 ppm	50 ppm	100 ppm	10 ppm	50 ppm	100 ppm
5	1.49	3.87	3.52	13.78	13.74	15.72
10	10.55	9.97	4.81	52.54	23.43	24.62
30	37.88	11.36	8.23	76.39	48.58	36.38
60	84.59	34.07	9.72	81.86	67.60	42.48

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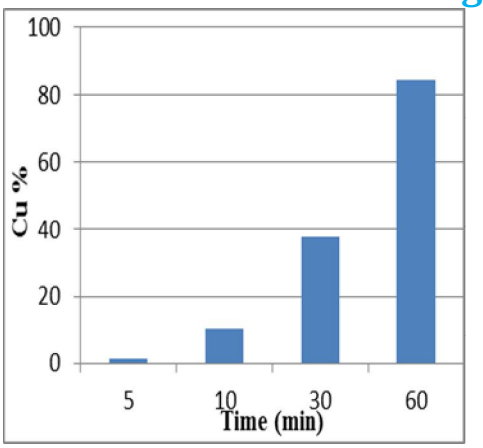
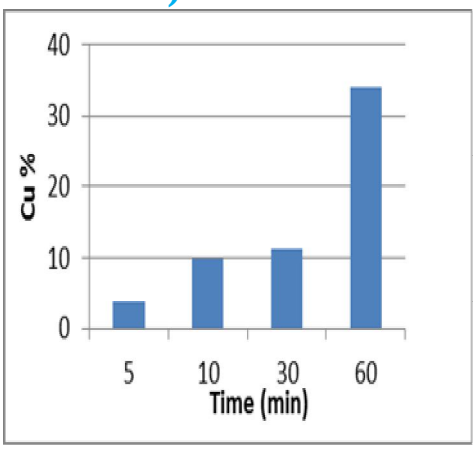
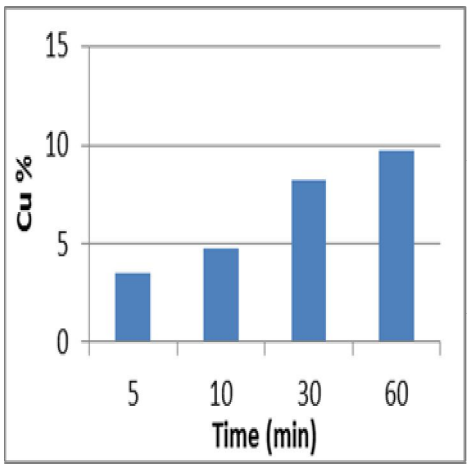


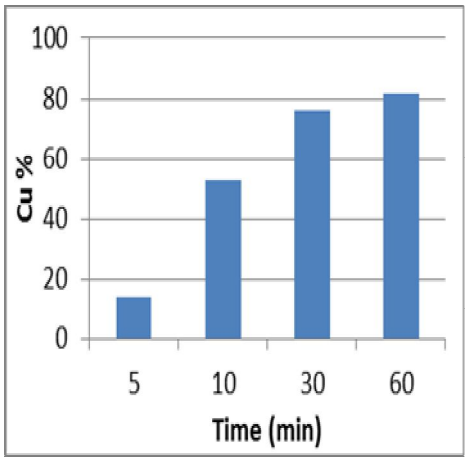
(a) Cu % 90µ (10ppm)



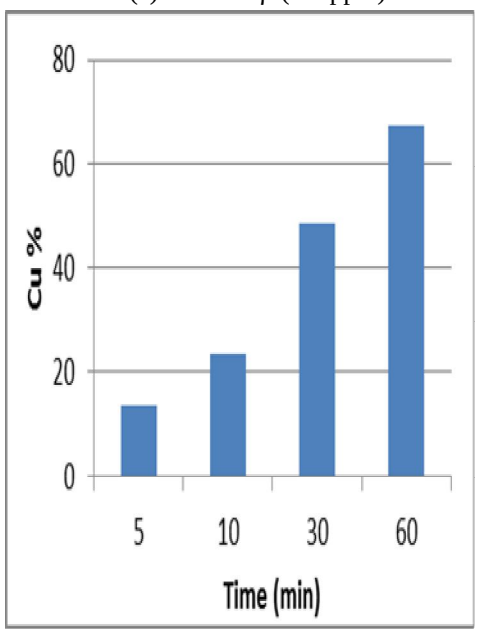
(b) Cu % 90µ (50ppm)



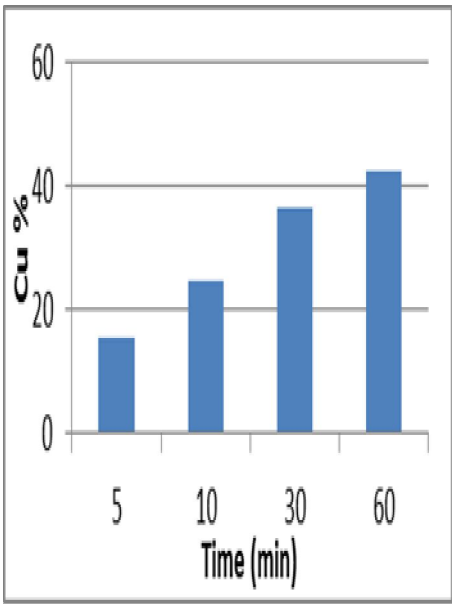
(c) Cu % 90µ (100ppm)



(d) Cu % 300µ (10ppm)



(e) Cu % 300µ (50ppm)



(f) Cu % 300µ (100ppm)

Fig-1 (a) to (f): Removal of Cu % using coal fly ash for various concentrations and periods.

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TABLE-II: Analysis of Cu % using coal fly ash (90µ) by Freundlich Isotherm

Metal ion concentration in ppm	q	q_{max}	K	1/n	R^2
10	2.632	0.3799	1.10	0.454	0.837
50	3.027	0.3303	2.80	0.461	0.887
100	2.922	0.3422	2.62	0.370	0.910

TABLE-III: Analysis of Cu % using coal fly ash (300µ) by Freundlich Isotherm

Metal ion concentration in ppm	q	q_{max}	K	1/n	R^2
10	2.870	0.3484	2.20	0.188	0.861
50	3.489	0.2866	2.75	0.183	0.904
100	3.583	0.2790	3.35	0.294	0.969

The intercept Kf value is an indication of the adsorption capacity of the adsorbent; the slope 1/n indicates the effect of concentration on the adsorption capacity and represents adsorption intensity. As seen from Table II and III, n value was found high enough for separation. The Freundlich adsorption constants calculated from the corresponding isotherms with the correlation coefficients are presented in Table II and III. The correlation coefficient from 0.837 to 0.969 that was nearly equal to ideal graph of the copper metal ion.

IV. CONCLUSIONS

The following conclusion had withdrawn from present study:

A. The harvesting of activated carbon from coal ash is relatively simple procedure and had obtained without excessive cost.
B. Efficiency of the coal ash indicates that it is effective to remove metals ion from single metal solution (SMS).
C. From this kinetic studies, it is observed that adsorption of copper metal on coal ash is very rapid in final stage.
D. The percentage removal of copper metal was increases with the increases in adsorbent dose and decreases with increase in initial and final concentrations of metals ion.
E. Experiments results are good agreement with Freundlich adsorption isotherm model.
F. Metal adsorption is very quick process. Although the time has positive effects on the removal of heavy metals, a sharp decrease in metal concentrations occurs within 60 min.
G. The amount of fly ash has a positive effect on removal of heavy metal ions from industrials wastewater.

V. ACKNOWLEDGMENT

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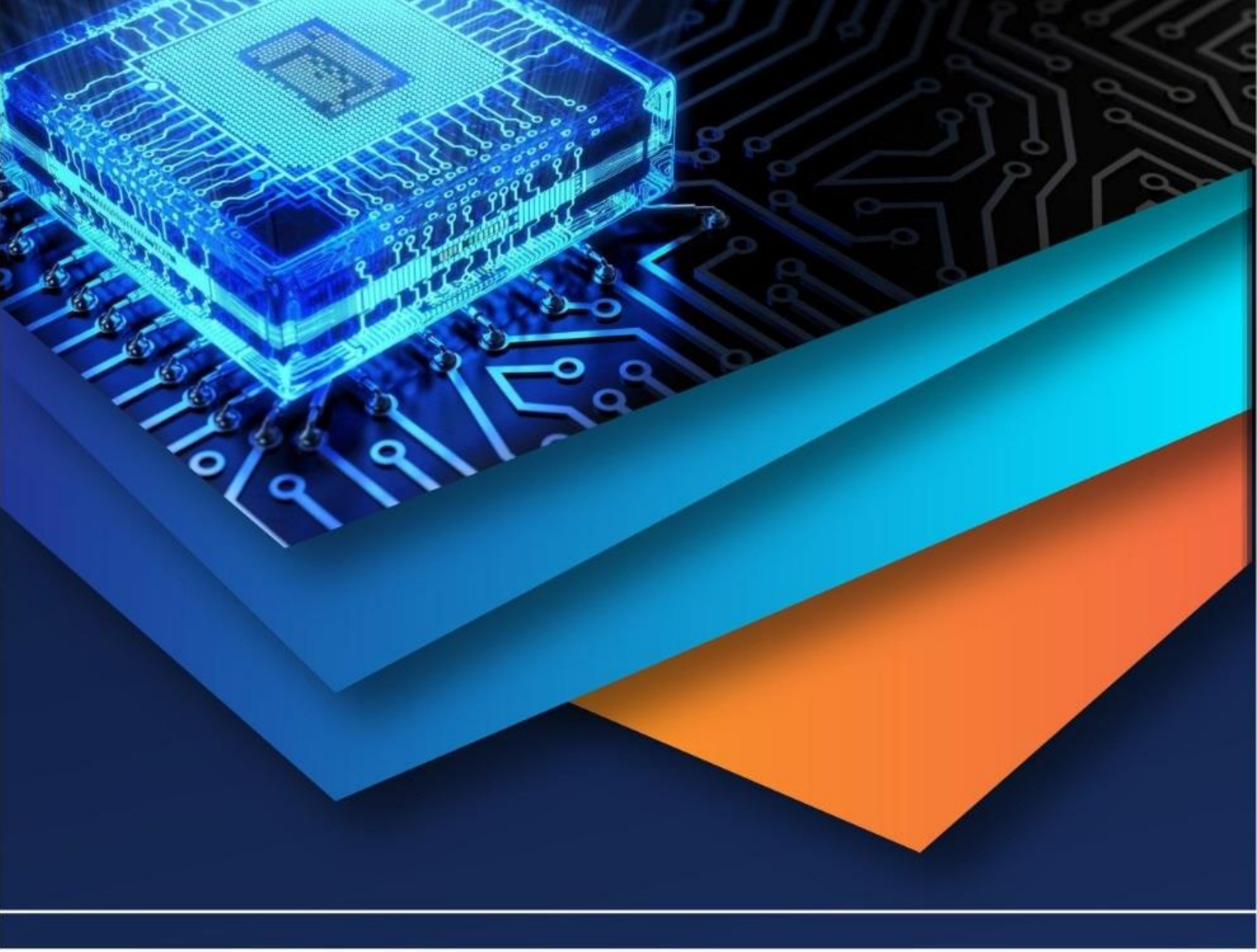

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